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VOLUME 2 MARCH, 1956 Nos. 1~2

THE JOURNAL OF GENERAL AND APPLIED MICROBIOLOGY

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Published Quarterly By

THE INSTITUTE OF APPLIED MICROBIOLOGY

THE UNIVERSITY OF TOKYO

TOKYO JAPAN

COMMONWEALTH MYCOLOGICAL INSTITUTE
5 NOV 1956

The Journal of General and Applied Microbiology is issued quarterly by the Institute of Applied Microbiology, University of Tokyo.

The journal is distributed without charge to, preferably in exchange with similar publications from, outstanding scientists and scientific organizations interested in microbiology and related fields.

Correspondence concerning the journal should be addressed to the Institute of Applied Microbiology, University of Tokyo, Bunkyo-ku, Tokyo, Japan.

J. Gen Appl. Microbiol.
Vol. 2, Nos. 1~2, 1956

STUDIES ON THE CLASSIFICATION OF THE *PENICILLIA*

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Received for publication Feb. 1, 1956

INTRODUCTION

The first adequate illustration of a mold unquestionably representing a *Penicillium* was given in the 1809 publication of Bulliard and Ventenat, in which *Mucor* penicillatus represented the broom or brush-like forms.

The generic name, *Penicillium*, applied to fungi, first appeared in Link's "Observation" (1809), in which he described very briefly the genus and three species: *Penicillium glaucum*, *P. candidum*, and *P. expansum*.

Following this, numerous studies of the *Penicillia* were reported and several subgenera were proposed: Persoon (1797, 1886) described *Isaria* and *Monilia*; Link (1809) described *Coremium*; Corda (1839, 1840) described *Clonostachys* and *Fliocladium*; Harz (1871) described *Spicaria*; Baranetzky (1872) described *Gymnoascus*; Sorokin (1879) described *Metarhizium*; Costantin (1888) described *Synpenicillium*; and Ludwig (1892) described *Eupenicillium*.

In addition, Micheli (1729), Fries (1829), Greville (1823–1828), Bonorden (1851), Fresenius (1850–1863), Preuss (1851–1853), Montagne (1856), Cooke (1871–1891), Rivolta (1873), Berkeley (1841, 1875), Saccardo (1886) and others published their studies on the *Penicillia* and related genera.

Wehmer (1893) used the generic name *Citromyces*, and subgeneric *Verticillatae*, and in 1901 proposed the name *Microaspergillus*. He also reported on the physiological and biochemical activities of the *Penicillia* in 1906.

Dierckx (1901) described as new 25 species, and proposed a subgenus *Aspergilloides*, for the monoverticillate form.

Thom (1906) published "Fungi in Cheese Ripening", and Bainier (1907) proposed the genera *Paecilomyces* and *Scopulariopsis*; Brefeld (1908) proposed the name *Lysipenicillium*, and published the life history of *Penicillium glaucum* (1874); Westling (1909) proposed the generic name, *Byssochlamys*; he also classified *Eupenicillium* on the basis of the size of conidia and described the *Aspergilloides* in 1912.

Sopp (1912) published many figures covering some sixty species of *Penicillium* and proposed the new genera *Acaulium*, *Aspergillopsis*, *Corollium*, *Dactylomyces* and *Styanus*. He classified these five on the basis of conidial color and described ten strains of *Aspergilloides*.

Biourge (1923) gave a brief Latin diagnosis for some 125 species, and in his Monograph he classified the *Penicillia* on the basis of the character of conidiophore, penicillus, conidia, color and color change, etc, and proposed

the subgenus *Monoverticillum*. In this Monograph, he divided the *Penicillia* into the two subgenera, *Eupenicillium* and *Monoverticillium* (*Aspergilloides* Dierckx 1901), and divided the former into two sections, *Bulliardium* or *Asymmetrica* and *Biverticillium* Dierckx (1900); he further divided the first section into six sub-sections, and the second into four series.

Zaleski (1927) described 35 new species and one new variety of *Penicillium* from the forest soils of Poland, and he accepted the classification given in Biourge's Monograph, fitting his species into this scheme insofar as possible.

Thom (1930), in his comprehensive Monograph, brought together all of the material on the taxonomy of cultures grown in the laboratory under uniform conditions and empasized the importance of observations made on growing colonies and developing conidial structure. In this work the genus *Penicillium* was divided into four groups, Monoverticillata, Asymmetrica, Biverticillata-Symmetrica, and Polyverticillata-Symmetrica; *Pacilomyces*, *Gliocladium* and *Scopulariopsis* were separated from *Penicillium* but were treated as related genera. Thom described 678 species; the Monoverticillata group was divided into Monoverticillata-stricta and Monoverticillata-ramigena and the former was divided into four sub-section; the Asymmetrica group was divided into six sections, the Velutina into six sub-sections, and the Fasciculata into six sub-sections; the Biverticillata-Symmetrica group was divided into four sections, and the Luteo-viride into two series.

Since 1930, investigators have described a number of new species: *P. javanicum* van Beijma (van Beyma) 1929; *P. sclerotiorum* van Beyma, 1937; P. *phoeniceum* van Beyma, 1933; *P. velutinum* van Beyma, 1935; *P. baarnense* van Beyma, 1939, 1940; *P. egyptiacum* van Beyma, 1933; *P. humuli* van Beyma, 1939; *P. novae-zeelandiae* van Beyma, 1939–1940; *P. ehrlichii* Klebahn, 1930; *P. nalgiovensis* Laxa, 1932; *P. bacillosporum* Swift, 1932; *P. brefeldianum* Dodge, 1933; *Carpenteles asperum* Shear, 1934; Emmons, 1935; *P. charlesii* Smith, 1933; *P. raistrtckii* Smith, 1933; *P. pallidum* Smith, 1933; *P. varirns* Smith, 1933; *P. pusillum* Smith, 1939; *P. carneo-lutescens* Smith, 1939; *P. stipitatum* Thom, 1935; *P. pulvillorum* Turfitt, 1939; *P. reticulosum* Bierkinshaw, Raistrick and Smith, 1942; *P. purvum* Raper and Fennell, 1948; *P. levitum* Raper and Fennell, 1948; *P. lapidosum* Raper and Fennell, 1948; *P. capsulatum* Raper and Fennell, 1948; *P. helicum* Raper and Fennell, 1948; *P. rotundum* Raper and Fennell, 1948; *P. striatum* Raper and Fennell, 1948; *P. piceum* Raper and Fennel, 1948; *P. aculeatum* Raper and Fennell, 1948; *P. diversum* Raper and Fennell, 1948; *P. diversum* var. aureum Raper and Fennell, 1948.

In the classification given by Raper, Thom and Fennell in their work, "A Manual of the Penicillia" (1949), all the described species were readjusted and the species named after 1930 were added; a total of 137 species was recognized.

The primary basis of separation within the genus *Penicillium* rests upon the pattern and complexity of the conidial structure, or penicillus.

Raper, Thom and Fennell accepted the divisions used in Thom's classification, and his four major sections.

The second basis of separation is whether or not perithecia or sclerotia are produced. The third basis of separation is that of colony characteristics.

The basis of separation within the five sub-sections in the Asymmetrica, rests primarily on the texture and pattern of the surface, or the nature of aerial growth. Sub-sections and series are established upon the following bases: colonies are regarded as velvety, floccose or lanose, funiculose, fasciculate or coremiform in appearance. The additional bases of separation are the pigmentation of conidia and the colony reverse, the rate of growth on common laboratory media, and the pattern of mature conidial chains. Here again, separation may depend upon the detailed structure of the penicillus, the pattern or character of the sterigmata, the form and markings of the conidiophores, or the shape and dimensions of the conidia.

By the combination of the criteria described above, forty one series were classified and the major sub-sections were determined in the Asymmetrica.

In Japan, numerous reseachers have described *Penicillia*: species and varieties have been described by Sakaguchi (1930), Hanzawa (1931), Nakazawa, Takeda and Suematu (1932), Nehira (1933), Nakazawa, Takeda, Okada and Shimo (1934), Nakazawa, Takeda and Suematu (1934), Ootomo (1935), Sakaguchi, Inoue and Tada (1938), Sakaguchi and Saito (1939), Miyake, Naito and Tsunoda (1940), Suzuki (1941), Munekata (1943), Sasaki and Nakane (1943), Sakaguchi, Munekata, Hisadaka and Kitagima (1946), Nakane (1946), Sasaki (1946), Nehira (1947), Umezawa, Mizuhara, Uekane and Hagihara (1947), Kondo (1947), Saito and Minoura (1948), Terui and Shibazaki (1948), Ohtsuki, Miyashita and Imai (1948), Kominami and Yoneshige (1948), Saito, and Minoura (1949), Shimazono and Arima (1949), Omasa, Kawada and Nagashima (1951), Abe, Shiga and Nakano (1952), and Tsunoda (1953).

Thirteen species and two varieties of *Penicillium* were described as new: *P. albosimplex* Nehira, 1933; *P. echinosporum* Nehira, 1933; *P. viniferum* Sakaguchi, Inoue and Tada, 1938; *P. biforme* var. *vitriolum* Sakaguchi and Sato, 1939; *P. cuprophilum* Sakaguchi and Sato, 1939; *P. toxicarium* Miyake, Naito and Tsunoda, 1940; *P. noproensum* Sasaki and Nakane, 1943; *P. yezoensum* Hanzawa, 1943; *P. parallelosporum* Sasaki, 1946; *P. ellipticum* Sasaki, 1946; *P. spinulo-ramigenum* Sasaki, 1946; *P. crustosum* var. *spinulosporum* Sasaki, 1946; *P. oligosporum* Saito and Minoura, 1948; *P. velutinum* Terui and Shibazaki, 1948; *P. luteo-caeruleum* Saito, 1949.

The following well-recognized species were isolated in Japan: *P. biourgeianum* Zaleski (Nakazawa, Takeda and Suematu, 1934); *P. carmino-violaceum* Dierckx (Sasaki, 1946); *P. citreo-viride* Biourge (Sasaki, 1946); *P. citreo-sulfuratum* Biourge (Sasaki and Nakane, 1943); *P. chrysogenum* Thom (Sakaguchi, Munekata, Hisadaka and Kitagima, 1946; Shimazono and Arima, 1949; Abe, Shiga and Nakano, 1952); *P. citreo-roseum* Dierckx (Sasaki, 1946); *P. citrinum* Thom (Kominami and Yoneshige, 1948; Abe, Shiga and Nakano,

1952); *P. columnare* Thom (Sasaki, 1946); *P crustaceum* Fries (Sasaki, 1946); *P. cyaneo-fulvum* Biourge (Abe, Shiga and Nakano, 1952); *P. cyclopium* Westling (Omasa, Kawada and Nagashima, 1951); *P. expansum* Link (Hanzawa, 1932; Sasaki and Nakane, 1943; Sasaki, 1946); *P. fellutanum* Biourge (Sasaki, 1946); *P. flavo-glaucum* Biourge (Sasaki, 1946); *P. flutans* Tiegs (Nakane, 1946); *P. glauco-griesum* Sopp (Sasaki and Nakane, 1943); *P. godlewskii* Zaleski (Hanzawa, 1931); *P. islandicum* Sopp (Tsunoda, 1953); *P. janczewskii* Zaleski (Sasaki, 1946); *P. janthinellum* Biourge (Hanzawa, 1931; Sasaki and Nakane, 1943; Omasa, Kawada and Nagashima, 1951); *P. luteum* Zukal (Hanzawa, 1931; Omasa, Kawada and Nagashima, 1951); *P. notatum* Westling (Shimazono and Arima, 1949; Abe, Shiga and Nakano, 1952); *P. paczoskii* Zaleski (Sasaki, 1946); *P. palilans* Westling (Sasaki, 1946); *P. pfefferianum* or *Citromyces pfefferianus* Wehmer (Hanzawa, 1931; Sasaki, 1946); *P. puberulum* Bainier (Nakane, 1946); *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom (Omasa, Kawada and Nagashima, 1951); *P. rivolii* Zaleski (Sasaki and Nakane, 1943); *P. roqueforti* Thom (Sasaki, 1946; Nakane, 1946); *P. rugulosum* Thom (Omasa, Kawada and Nagashima, 1951); *P. sanguineum* Sopp (Omasa, Kawada and Nagashima, 1951); *P. sartoryi* Thom (Sasaki, 1946); *P. simplicissimum* (Oud) Thom (Sasaki and Nakane, 1943); *P. solitum* Westling (Sasaki, 1946); *P. spinulosum* Thom (Sasaki, 1946; Omasa, Kawada and Nagashima, 1951); *P. terlikowski* Zaleski (Sasaki, 1946); *P. trzebinskii* Zaleski (Nakane, 1946); *P. umbonatum* Sopp (Hanzawa, 1931); *P. verrucosum* Dierckx (Hanzawa, 1931); *P. viridicatum* Westling (Abe, Shiga and Nakano, 1952); *P. waksmani* Zaleski (Hanzawa, 1931, Sasaki and Nakane, 1943; Sasaki, 1946).

Studies on penicillin producing strains have been reported by Fleming (1944); Raper, Alexander and Coghill (1944); Raper and Alexander (1945); Thom (1945); Gailey, Stefaniak, Olson and Johnson (1946); Backus, Stauffer and Johnson (1946); Whiffen and Savage (1947); Reese et al (1949); Kubo and Imai (1947); Hosoya and Soeda (1949); Ohtani and Okada (1950); Arima et al (1950).

In this report descriptions of well-known penicillin producing strains (variants or mutants) are generally omitted. However, strains newly isolated from natural sources are described.

The author has collected about 3,500 samples, from Universities and Laboratories in Japan. These were obtained from the soil of different places and from other various materials.

About 10,000 strains were isolated from these samples, and from them about 3000 strains were first selected on the basis of colony and microscopic characters, from these 1,200 strains were selected by observation during continuous monospore culture.

In addition, in this study about 100 strains of *Penicillium* and 50 strains of *Citromyces* from the collection in Tokyo University described by Sakaguchi (1930), *Penicillia* sent from many investigators in Japan as unknown species, and thirteen strains sent by Drs. K. B. Raper and D. I. Fennell, University

of Wisconsin to Dr. K. Sakaguchi in 1952 were studied.

All of the 1,350 strains currently described have been under observation for a period of at least three years, and some for more than five years.

This report, will described those strains which are normal; yeast types, sterile types, and types having irregular or undeterminable penicilli and colonies will be described in later reports.

All of the strains studied were assigned to species or varieties chiefly according to Raper, Thom and Fennell's classification, and many differences were found between this and other reports. Fourteen species and 13 varieties, as well as three mutations of *Penicillium*, are described as new.

A total of 116 species and varieties from about 2000 strains are classified on the basis of morphological characters.

In earlier classifications, morphological characters form the chief basis for division, but in this report, the following additional techniques and characters were employed.

The rate of growth on the laboratory media at 5°, 15°, 25°, 30° or 37°C, is shown to be a characteristic of individual strains, and is character is recognized as useful for classification of species, series and sections in the genus *Penicillium*. The optical microscope, electron microscope, and extensive observations by electron micrograph were used to get correct data on differences in the character of walls in new species and varieties and some other species in which markings were doubtful. Whether or not growth occured on Sakaguchi & Wang agar was recognized as another useful point for classification.

The following characters were also investigated: the antifungal or antibacterial activities; the color or color changes of the broth pigmentation due to pH; precipitations due to changes of pH; the extractability of pigments in the broth by various solvents; the $FeCl_3$ reaction and reducing power after extraction by ether. The production of various substances was recognized as a useful point for classification.

Yellow, purple, blue-purple, etc., shades of fluorescent substances were produced by about 50 species. The investigation of pectin clarification activity uncovered strains that were useful in industry, and two other strains (*P. lilacinum* and *P. funiculosum*) useful to the dextran industry were found.

By the combination of morphological and biochemical characters as described above, a new classification of the genus *Penicillium* was made.

PART I MORPHOLOGICAL CHARACTERISTICS

I. EXPERIMENTAL METHODS

1. Materials.

About 3,500 cultures were obtained from the soil of different places in Japan and from other materials (fruits, vegetables, corn, flowers, leaves, refuse, decaying materials, etc.).

2. Media.

Czapek agar (distilled water, 1 liter; sucrose, 30 gms.; $NaNO_3$, 3.0 gms.; K_2HPO_4, 1.0 gm.; KCl, 0.5 gm.; $MgSO_4 \cdot 7H_2O$, 0.5 gm.; $FeSO_4 \cdot 7H_2O$, 0.01 gm.; agar 20 gms. The pH is nearly neutral and is not adjusted.) Modified Czapek agar (distilled water, 1 liter; glucose, 10 gms.; $NaNO_3$, 2.0 gms.; K_2HPO_4, 1.0 gm.; KCl, 0.5 gm.; $MgSO_4 \cdot 7H_2O$, 0.5 gm.; $FeSO_4 \cdot 7H_2O$, 0.01 gm.; agar, 30 gms. Adjust pH to 4.3 to 4.4 with 0.2 N·HCl.) Sterilization, 120°C, 20 minutes in autoclave.

3. Isolation and screening tests.

For the isolation of *Penicillia* from natural materials, dilution and streak cultures were used. Usually spores were transferred to Czapek agar slants from spot colonies in petri dishes grown at 25° or 30°C for 4 to 5 days; the slants were then incubated at 25°C for 5 to 7 days. About 3,000 strains were selected from about 10,000 newly isolated strains on the basis of colony character. Continuous monospore culture was then carried on for all 3,000 strains, and from these about 1,200 strains were selected by rigid observation of colony characteristics.

4. Observation or description of *Penicillia*.

A. Culture media.

(1) Czapek agar: as described above.

(2) Steep agar: Czapek agar plus the addition of 10 gms concentrated corn steep liquor. The pH was adjusted to 7.0 with NaOH before sterilization.

(3) Malt extract agar: 1 kg. saccharified malt is dissolved in 5 liters distilled water at about 65°C, filtered, made up to 10 Ballg. solution, and adjusted to pH 4.7; 20 gms agar per liter were added and the medium was sterilized.

(4) Koji extract agar: 1 kg. Koji is saccharified in about 5 liter distilled water at about 60°C, filtered, made up to 10 Ballg. solution, and adjusted to pH 6.0; 20 gms. agar per liter were added and the medium was sterilized.

(5) Corn meal agar: 50 gms. white corn meal (contained in cloth bag) were boiled in one liter distilled water for one-half hour, filtered, and made up to original volume; 20 gms. agar were added and the medium was sterilzed.

(6) Hay infusion agar: 50 gms. decomposing hay was autoclaved in one liter of distilled water for 30 minutes, and filtered. Two gms. K_2HPO_4 and 20 gms. agar per liter of infusion filtrate were added, pH adjusted to 6.2 with HCl and the medium was sterilized.

(7) 20 per cent sucrose Czapek: Similar to 1, except that 20 per cent sucrose instead of 3 per cent was added. The pH was nearly neutral and was not adjusted.

B. Mono-spore culture (Dilution method) and Spot culture.

Normal strains, which were found to be the same as when isolated from natural sources by mono-spore cultures (dilution culture), were used

for diagnosis. The diagnostic technique usually employed was spot inoculation of agar plates with massses of conidia from a selected area of the normal strains grown on Czapek agar slants which had been incubated at 25°C for 5 to 7 days.

Standard petri dishes, 87 mm. in inside diameter and about 15 mm. deep, were filled to a depth of about 4 mm. with melted agar medium at 45°C to 50°C.

We usually used three identical plates for each test, with one colony per plate, and these were incubated at 25°, 30° and 37°C.

C. Observation and description.

(1) Colony characteristics.

1. Rate of growth: Colony diameter after 5 days, 10 to 12 days and 20 to 22 days at various temperatures.
2. Colony depth: A film of colony and substratum was cut out of the colony center, mounted on a glass slide, and the colony depth was measured at the margins, in the subcentral area, and in the central area, after 5 to 6 days and 10 to 12 days.
3. Texture of colony: Examined by naked eye, hand-lens, and low power of the microscope; texture were classified as velvety or velutionous, subfloccose or floccose and lanose, funiculose, and fasciculate or coremiform, after Raper, Thom and Fennell's description (1949).
4. Character of surface: The colony surface examined by hand lens or naked eye, was described as smooth, plane or thin, wrinkled or furrowed, and color of the mycelium*, and zonate or azonate characters were noted.
5. Character of margin: The characteristics of the colony margin, such as smooth, compact, mealy or granular, fascicle, thin, narrow, broad, etc., color, and width of the marginal zone were examined by naked eye, hand-lens, and low power of the microscope.
6. Colony color and color change: Color and shades of conidial areas were classified according to Ridgway's standard after 10 to 12 days and 20 to 22 days. In some cases, colors were listed separately for marginal, subcentral, and central areas (abbreviated as respectively, MA, SCA, and CA).

   Any characteristic color change during growth was also noted.
7. Colony reverse: Color and shades of colony reverse were described in the same way as for 6.
8. Exudate: Transpiration of fluid is a conspicuous feature, and the presence or absence, amount and color were observed.
9. Pigmentation of substratum: Agar pigmentation is a conspicuous feature, and color and shades, width of pigmentation zone after 10

* Color description (Capital) given in Ridgway "Color Standards And Nomenclature". 1912, are used throughout this work.

to 12 days and 20 to 22 days, and characteristic color and shade changes during a growth period of 4 to 5 weeks, were described.

(2) Microscopic characteritics of conidia formation.

Details of structure were observed or measured by direct observation and also by observation of dry mounts or fluid mounts under microscope.

1. Direct observation: Data conidial chain and conidiophore lengths, shape of conidial chains, perithecia and sclerotia, number and arrangement of sterigmata, metulae, etc., were obtained by direct observation of the undisturbed colony or slant under the microscope.
3. Dry mounts: Data on size, form and marking of conidia, sterigmata, metulae, branches, conidiophore, sclerotia, perithecia, etc., were obtained by microscopic observation of direct dry mount preparations on glass slides.
3. Fluid mounts: Small masses of conidial structures were picked from the central, subcentral or submarginal conidial area, quickly washed in 70% alcohol on a glass slide, then mounted in a special fluid (glycerine, 2: alcohol, 1: water, 3.), and sealed with melted paraffin to form a semi-permanent preparation.

   Data on the diameters of apices and the dimensions of sterigmata, metulae, branches, conidiophores, asci, ascospores, etc., were obtained by observation of fluid mount preparations under the microscope.
4. Electron micrograph observations: Conidia obtained from Czapek agar cultures, incubated for 22 to 30 days at 25°C were put on a clean 200 mesh copper screen on which a thin "Formvar" (Vinyl acetate formaldehyde polymer) film or Collodion-SiO film had previously been mounted and dried.

   The specimens were examined with an HITACHI type HU-4 electron microscope. The electron micrographs were all taken at an electronic magnification of 2500 or 3000 and then enlarged.

II. BASES FOR CLASSIFICATION

A colony of *Penicillium* typically exhibits certain striking characteristics. The cultural characteristics are as follows: restricted or broadly spreading colony; velvety, floccose, funiculose, fasciculate or coremiform texture; thin or deep, and furrowed or wrinkled; production of zonation; color and color changes of conidial area and mycelium; color and shades of exudate and reverse, their changes, and pigmentation of substratum; production of odors, and if produced, the special smell, and influence of the changes of cultural conditions upon these characters. The detailed stractural characteristics are as follows: whether or not perithecia or sclerotia are produced, and if produced, their appearance and form; form, size, and marking of conidia and character of conidial chains; usual number, arrangement, form, dimension, length, and marking of sterigmata; character of metulae and branches; origin, apices, dimension, length and marking of conidiophores; etc.

The nature of the source material, biochemical characters, etc., are also bases for classification.

The ideal classification of the genus *Penicillium* is normally based upon formation of perithecia so that the nature of the fungus as related to other genera may be explored.

In the Penicillia, however, a very small number of strains form perithecia.

In this classification stable characters common to certain groups are used as primary criteria and unstable characters or characters common to only a small groups of strains are used as secondary criteria.

The bases for classification are as follows.

1. The pattern and complexity of the conidial structure, or penicillus.

This basis of separation was divided into four major sections by Raper, Thom and Fennell (1949). Though there is a question about the relation between the Monoverticillata and the *Ramigena* or the *P. corylophilum* species, and there is no sharp line between the Monoverticillata and the Velutina in the Asymmetrica or the Divaricata, the following division on this basis is to be approved.

Monoverticillata: Conidial structures typically consist of a single verticil of sterigma, or conidium-bearing cells, terminating in a fruiting branch, or conidiophore. The conidiophores may arise directly from aerial hyphae, variously interwoven or, less commonly, arranged in more or less well-defined ropes. In certain forms the conidiophores are irregularly branched but the individual fruiting structure still retains its basic monoverticillate character.

Asymmetrica: Conidial structures are characteristically once-or twice branched below the level of the sterigma and are typically asymmetrical. The metulae, cellular elements bearing the sterigmata, occur in verticils terminating the main conidiophore or on one or more branches arising from it at the next lower node.

Biverticillata-Symmetrica: Conidial structures typically consist of single terminal verticils of metulae, each bearing crowded verticils of sterigmata that are characteristically lanceolate in pattern, with acuminate conidium-bearing tips. The overall appearance of the typical penicillus gives the impression of a fairly compact and completely symmetrical brush or broom.

Polyverticillata: Conidial structures are characterized by penicilli that are usually symmetrical and are branched at several levels below the sterigmata. Conidiophores are regularly short and heavy, and the cellular elements in the branching system are likewise typically short and comparatively thick.

2. Production or absence of perithecia or sclerotia.

Among our strains, the only one forming perithecia is FAT 364 of *P. wortmanni* Klocker. Strains forming sclerotia are the following: *P. sclerotiorum* van Beyma, FAT 1181; *P. thomii* Maire, FAT 388; *P. thomii* Maire var. *flavescens* Abe, FAT 340; *P. cinnamopvrpureum* Abe, FAT 362, 363; *P. purpurogenum* Stoll var. *rubri sclerotium* Thom, FAT 200, 808, 1210, 325 and 316. In the classification of Raper, Thom and Fennell (1949), *Penicillia*

forming perithecia included five species in the *P. javanicum* series, three species in the *Carpenteles* series, and eleven species in the *P. luteum* series.

They described thirteen sclerotia-forming species, five in the *P. thomii* series, four in the *P. raistrickii* series, and four in the Biverticillata-Symmetrica.

This is recognized, therefore, as important because perithecia and sclerotia are evidently characteristic of certain series and species of *Penicillium*, and their formation can be easily observed.

3. Colony characteristics and detailed structural characteristics.

(1) Texture.

Thom (1930) and Raper, Thom and Fennell (1949) distinguished four texture types; velvety, floccose or lanose, funiculose, and fasciculate or coremiform. They also set up four subsections; Velutina, Funiculose, Lanata, and Fasciculata, and used these as a basis in the separation of series in the Monoverticillata and the Biverticillata-Symmetrica.

The author occasionally found contradictions in species descriptions made on this basis, however. For example, in Raper, Thom and Fennell's (1949) description, *P. lividum* Westling and *P. aurantio-violaceum* Biourge of the *P. lividum* series having velvety in Monoverticillata, are described to be velvety to almost lanose; *P. trzebinskii* Thom is described as almost floccose but it is classified on the basis of velvety texture; and some strains of *P. multicolor* G.-M. and P. of the *P. implicatum* series are described as almost floccose instead of velvety; in *P. decumbens* Thom of the *P. decumbens* series, some strains are described as almost velvety and others, almost floccose instead of velvety or lightly floccose; *P. fellutanum* Biourge is described as composed of funiculose stolon-like hyphae instead of velvety or lightly floccose; and *P. phoeniceum* van Beyma, is described as somewhat floccose or funiculose instead of funiculose texture.

In addition, in the Asymmetrica, there are the following description: some strains of *P. citrinum* Thom are more or less floccose but it is classified on the basis of velvety texture; *P. meleagrinum* Biourge of the *P. chrysogenum* series is sometimes almost floccose instead of velvety; *P. cyaneo-fuvlum* Biourge is of loose-texture and often more or less floccose instead of velvety; *P. brevi-compactum* Dierckx of the *P. brevi-compactum* series is velvety to lanose or loosely-textured instead of velvety; and *P. stoloniferum* Thom is velvety to lanose in most strains, but more or less floccose in others instead of velvety.

In the Fasciculata subsection, *P. ochraceum* Thom is more or less floccose in some strains and almost velvety in others but it is classified on the basis of fasciculate texture; *P. olivino-viride* Biourge is almost velvety in some strains instead of fasciculate; and *P. puberulum* Bainier is velvety to somewhat granular in its colony surface instead of fasciculate.

In the biverticillata-Symmetrica as well, *P. purpurogenum* Stoll of the *P. purpurogenum* series is velvety, some strains tending to become floccose

but it is classified on the basis of velvety texture; *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom shows funiculose colonies instead of velvety; *P. tardum* Thom of the *P. rugulosum* series is floccose-funiculose instead of velvety; and *P. herquei* Bainier and Sartory of the *P. herquei* series shows deeply velvety to lanose instead of lanose texture. Further-more, strains FAT 839 and 570 of *P. frequentans* Westling shows velutinous, but evidently funiculose aerial hyphae, and FAT 1223 is typically funiculose; FAT 1186, 929, 1216 and 1230, which are recognized as *P. multicolor* G.-M. and P. by Raper, Thom and Fennell, have a floccose or loose texture; and *P. chermesinum* FAT 1287 is funiculose or floccose; some strains of *P. decumbens* Thom are typically velvety, and others are floccose and slightly funiculose; strains of *P. citreo-viride* Biourge are divided into three types, typically velvety or velutinous, typically floccose, and funiculose in texture; and *P. adametzioides* Abe is typically velvety in FAT 1301, but typically funiculose in FAT 1302.

In the Asymmetrica, *P. corylophilum* Dierckx, strains FAT 1090 and 1041, are velutinous or subfloccose; FAT 1054 and 917 of *P. chrysogenum* Thom of the *P. chrysogenum* series, are velutinous or subfloccose; and FAT 580, 635 and 699 of *P. cyaneo-fulvum* Biourge are velutinous of subfloccose.

In the Fasciculata subsection, many strains of each species show a slightly fasciculate texture which tends later to become velutinous or velvety.

In the Biverticillata-Symmetrica, FAT 1074, 1072, 1073 and 40 of *P. purpurogenum* Stoll are subfloccose; strains of *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom are of two types, velutinous and funiculose, and FAT 1232, 1193 and 1148 of *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom are velutinous on Czapek agar, but typically funiculose on steep agar; *P. herquei* Bainier and Sartory of the *P. herquei* series, has a typically floccose type and a typically velvety type; *P. para-herquei* Abe, FAT 971, 964, 824 and 670 of the *P. herquei* series (according to Raper, Thom and Fennell) are velutinous; and *P. estinogenum* Komatsu and Abe of the *P. herquei* series, is of typical velvety texture.

As described above, the separation of subsections and series on the basis of texture can be applied to may strains of the *Penicillia*, but this separation results in errors of assignment and contradictions in too many strains, and much skill and experience are needed to use this criterion successfully.

In this report the author cannot discuss the separation of four subsections in the Asymmetrica on this basis since no strains of the Funiculosa and the Lanata as classified by Raper, Thom and Fennell (1949) were obtained.

However, we cannot help concluding that there are too many questions and contradictions to approve the formation of six series in the Monoverticillata and four series in the Biverticillata-Symmetrica.

This cannot, therefore, be accepted without question as the third important basis for the classification of the genus *Penicillium*, as suggested by Raper, Thom and Fennell, though it is recognized to be important in expressing the specific characters of some strains or species.

(2) Rate of growth.

This character of all *Penicillia* will be described in the part on biochemical characteristics.

(3) Depth of colonies.

The depth of colonies as measured in the marginal, subcentral and central areas after 5 to 6 days and 10 to 12 days growth on Czapek agar and steep agar is described in Table M-1 to 20 to be published in the next volume of this journal.

The destribution of measurements all strains used in this study are shown in Table 1. In all strains the depth of the subcentral area on Czapek agar is less than 1000 to 1200 μ, and in only a few strains is the depth of the central area more than 1000 to 1200 μ. Strain FAT 1161 of *P. clavigerum* Demelius was exception, with colonies 6 to 8 mm. or 12 mm. deep.

One strain of the Monoverticillata which measured up to 3000 μ in depth was FAT 1223 of *P. frequentans* Westling; the strains of the Biverticillata-Symmetrica which were up to 4000 μ in depth were floccose strains FAT 954, 702 and 264 of *P. herquei* Bainier and Sartory.

On Steep agar the depth of colonies is similar to, or somewhat greater than, that on Czapek's agar.

The depth of colonies within a species was generally constant, but some fluctuation was seen in a few strains.

For example, strains of *P. frequentans* Westling show a depth of 200 to 500 μ in the subcentral area and 300 to 800 μ or 3000 μ in the central area, and strains of *P. herquei* Bainier and Sartory measured 400 to 2000 μ in the subscentral area and 800 to 2500 or 4000 μ in the central area.

Therefore, since most species are limited to dimensions of less than 1000 μ, the classification or grouping of species in the *Penicillia* on this basis is not possible as it is in *Aspergillus* (Sakaguchi and Yamada, 1944).

This character was not used in any classification of the Penicillia, and it is of limited use only in the separation of strains.

4) Character of the surface.

The surface characters are as follows: zonation; color and color change of mycelium; plane or smooth, thin or deep, furrowed or wrinkled, and their degrees; sterile overgrowth; etc.

a) Zonation.

Munk (1912) reported that surface growth in zones is a conspicuous feature in many species and discussed it extensively. Biourge (1923) used the degree of zonation as a criterion for separating six-subsections in the Builliardium or Asymmetrica section of *Eupenicillium*, for forming the Zonata or Concentrica subsection and for separating the Euzonata and Hemizanata in 30 strains of *Penicillium*.

Thom (1930) and Raper, Thom and Fennell (1949), however, noted that although this character may be a conspicuous chararacteristic in some species, it is not an important basis for classification of the *Penicillia*.

Table 1. Depth of colonies on Czapek and steep agar.

A. Czapek agar.

Section and Subsection	Colonies area	−100 μ	−200 μ	−300 μ	−400 μ	−400 μ	−600 μ	−700 μ	−800 μ	−900 μ	−1000 μ	−1100 μ	−1200 μ	−1300 μ	−1400 μ	−1500 μ	−1600 μ	−1700 μ	−1800 μ	−1900 μ	−2000 μ	−2300 μ	−2400 μ	−2500 μ	−3000 μ	−4000 μ	−5 mm.	−12 mm.
Monoverticillata	Sub-central	1	12	27	34	20	7	7	12	—	5	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Central	—	1	6	8	16	22	6	17	1	17	4	10	7	8	3	—	—	—	—	—	—	—	—	1	—	—	—
Asymmetrica Divaricata	Sub-central	—	—	—	3	22	24	9	5	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Central	—	—	—	—	—	2	4	14	6	14	1	11	5	6	2	—	—	—	—	—	—	—	—	—	—	—	—
Asymmetrica Velutina	Sub-central	—	6	37	46	43	9	7	10	5	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Central	—	—	4	20	21	11	17	31	10	16	4	12	7	3	9	—	—	—	—	—	—	—	—	—	—	—	—
Asymmetrica Fasciculata	Sub-central	—	—	—	9	11	33	10	5	2	6	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
	Central	—	—	—	—	—	6	9	16	5	10	7	13	3	—	5	3	—	1	—	2	—	2	—	—	—	—	1
Biverticillata Symmetrica	Sub-central	1	2	27	38	13	1	3	7	6	5	0	1	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—
	Central	—	—	1	13	23	18	8	12	6	4	0	3	—	4	6	2	—	3	—	—	1	—	1	—	2	—	—
Polyverticillata	Sub-central	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Central	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

B. Steep agar.

Section and Subsection	Colonies area	−100 μ	−200 μ	−300 μ	−400 μ	−500 μ	−600 μ	−700 μ	−800 μ	−900 μ	−1000 μ	−1100 μ	−1200 μ	−1300 μ	−1400 μ	−1500 μ	−1600 μ	−1700 μ	−1800 μ	−1900 μ	2000 μ	2300 − 2400 μ	2500 − 3000 μ	4000 μ	−5 mm.	−12 mm.
Monoverticillata	Sub-central	—	3	24	39	15	11	10	14	4	3	2	—	2	—	—	—	—	—	—	—	—	—	—	—	—
	Central	—	—	4	9	12	16	12	16	—	17	2	16	10	5	4	—	—	1	2	—	—	—	1	—	—
Asymmetrica Divaricata	Sub-central	—	—	—	—	10	25	18	8	3	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Central	—	—	—	—	—	1	3	10	7	7	4	7	7	7	7	—	1	4	—	—	—	—	—	—	—
Asymmetrica Velutina	Sub-central	—	—	35	47	33	17	12	7	6	2	4	—	2	—	—	—	—	—	—	—	—	—	—	—	—
	Central	—	—	2	14	15	10	7	23	14	15	17	12	11	10	7	3	1	3	—	1	—	—	—	—	—
Asymmetrica Fasciculata	Sub-central	—	—	1	4	27	25	6	2	5	5	—	6	—	—	—	1	—	—	—	—	—	—	—	1	—
	Central	—	—	—	—	—	3	4	10	5	14	4	15	1	5	5	9	—	—	—	—	1	—	4	2	—	1	—
Biverticillata Symmetrica	Sub-central	—	—	10	11	12	2	13	12	7	5	—	2	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—
	Central	—	—	—	7	12	7	3	13	8	17	4	7	—	1	2	4	—	6	—	5	4	—	2	2	3	—	—
Polyverticillata	Sub-central	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Central	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

In this study, the author found conspicuous zonation in *P. claviforme* Bainier, FAT 1162, 1263, 1266, 554, 135 and 739, *P. tardum* Thom, FAT 922, 923, 1183, 1184, 1206 and 921, *P. islandicum* Sopp, FAT 1212, etc., but observed some fluctuation among strains of the same species. There seemed to be no correlation between strains of the same series or subsection.

Accordingly, zonation is somewhat useful for the separation of strains, but it is not very important for classification.

b) Color of the mycelium on the colony surface.

The mycelium of many *Penicillia* is color-less. But the strains of *P. multicolor* G.-M. and P. in the Monoverticillata, and many strains of the Biverticillata-Symmetrica are colored yellow, orange, red, brown, etc.

Thom (1930) and Raper, Thom and Fennell (1949) used the color of the mycelium as a secondary basis for forming sections in the Biverticillata-Symmetrica.

However, the use of color for classification is not applicable to all species or varieties.

But this character is only a conspicuous characteristic of some species, and it is not recognized as more than a subbasis of separation in the other sections.

c) Furrowed or wrinkled, plane or smooth, etc.

The Radiata subsection which Biourge (1923) proposed, and Thom (1930) accepted, was assigned to the *P. chrysogenum* series by Raper, Thom and Fennell (1949).

Many strains of this series developed radially furrowed or wrinkled colonies, and this seemed characteristic of the series.

Some strains of *P. chrysogenum* Thom and *P. meleagrinum* Biourge var. *viridi-flavum* Abe which are assigned to the *P. chrysogenum* series by Raper, Thom and Fennell's classification, do not show the character, however.

The nature of the colony surface was useful in separating *P. roqueforti* Thom and *P. casei* Staub.

Other characters (thin, plane, central area raised, etc.) were used in separating the *P. rugulosum* series in Raper, Thom and Fennell's classification, but they are not useful for the species in this study.

In addition, strains of the same species sometimes developed different surface appearances; thus, the character is of limited usefulness in the classification of the *Penicillia*, and its may serve as a secondary basis of separation, useful in only separating species.

d) Sterile overgrowth.

In some strains, an area of sterile overgrowth sometimes developed with passage of time, even after pre-treatment of monospore cultures.

This character was recognized, for example, in strains of the *P. decumbens* series by Raper, Thom and Fennell. It is not useful as a basis for classification, and, in fact, it is apt to be a source of error by suggesting the production of perithecia and sclerotia. Overgrowth can often be prevented

by using the monospore method and by making a colony for observation as soon as possible.

(5) Character of the margin.

The character of the colony margin is useful in determing the relation between submerged mycelium, aerial hyphae, and conidiophore origin.

Thorough observation during growth is important in the determination of texture, the detection of conidiophore origin and the measurement of the length of conidiophores.

Thom (1930) and Raper, Thom and Fennell (1949) used the hand lens, binocular and optical microscopes in direct observation. The author used the same techniques, and the following additional method.

A section less than 0.5 mm. thick was cut from the colony, together with agar, between a point about 5 mm. outside of the margin and the center of the colony; this was mounted on a glass slide, and observed. The microscopical characters show some correlation with the texture, origin and length of conidiophores and other characters.

The marginal sterile area is generally colorless, but it is characteristically yellow, orange, brown, red, etc. in some species as described above, in 4(b).

Species or strains, except those belonging to the Biverticillata-Symmetrica, may be differentiated according to this coloration.

As most species or strains of the this group show marginal coloration, this character is almost useless for identifing individuals.

P. lividum Westling, FAT 877, 626, and 73, has a broad margin of about 3 to 5 mm., *P. funiculosum* Thom, FAT 71 and 1267, about 5 mm., and *P. herquei* Bainier and Sartory, FAT 1313, a thin broad zone about 10 mm. wide.

In *P. decumbens* Thom, FAT 1071, *P. decumbens* Thom var. *atro-virens* Abe, FAT 329, the zone was about 0.2 to 0.3 mm. wide, however, in *P. citero-viride* Biourge, FAT 568, 1176 and 1229, bout 0.2 to 0.5 mm., and in *P. herquei* Bainier and Sartory, FAT 953, 957 and 1028, 0.3 to 0.5 mm. wide.

Therfeore, each strain or each species evidently shows a characteristic width of margin, but this character is not recognized as an important basis for classification. The majority of the strains of *Penicillium* have a marginal zone of about 0.8 to 2.0 mm. Colonies of some strains or species develoved smooth or plane margins, others developed abrupt margins, while strains such as *P. roqueforti* Thom developed arachnoide or crenulate margins. Some strains of *P. stoloniferum* Thom, FAT 684, 815, 1202, 507 and 90 developed stolon-like aerial hyphae.

Biourge (1923) assigned the Bulliardium and the Asymmetrica subsections to Eupenicillium, and Thom (1930) accepted them and observed notched or stellate forms in a few strains.

The circumference of the colony in most strains of the *Penicillia* were smooth, however. Therefore, the character of the margin, the form of the circumference of the colony, etc., are characteristic only of individual strains and are not consistent between species.

The usefulness of this character is therefore limited to separating species or strains.

(6) Colony color and color change.

The majority of the strains of the genus developed greenish shades or colors in conidial areas, which then changed to yellowish-brown, reddish-brown, olive gray, or fuscous shades after the growing period.

Strains of the *P. lilacinum* and the *P. ochraceum* series did not develop greenish colors, however, but lilac, vinaceous, avellaneous or brownish shades.

Sopp (1912) separated this genus into five sections on the basis of the colors or shades of conidia; bluish-green, bluish-gray, yellowish-green, yellowish, whitish. This character was used by Raper, Thom and Fennell (1949) to separate the *P. lilacinum* and the *P. nigricans* series, the *P. janthinellum* and the *P. canescens* series, the *P. cammenberti* and the *P. commune* series, the *P. terrestre* and the *P. pallidum* series, and six series in the Fasciculata subsection of the Asymmetrica.

It is recognized as a important basis for classification.

In this study, the author agrees with most of the points in Raper, Thom and Fennell's ciassification (1949), but considers a few points doubtful.

For example, some strains assigned to *P. crustosum* Thom of the *P. expansum* series in the Fasciculata subsection of the Asymmetrica, developed yellowish-green shades, but others (FAT 1058, 1025, 847, 553, 1227, 143, 1303, 318, 705, 1018) developed slightly bluish-yellow-green shades in the conidial area. Thus, according to Raper, Thom and Fennell's classification (1949), these strains should not belong to the *P. expansum* series.

On the basis of color of conidial areas, FAT 887 of *P. aurantio-virens* Biourge should belong to the *P. viridicatum* series, and strains of *P. viridicyclopinm* Abe to both the *P. cyclopium* and the *P. viridicatum* series.

According to the color of conidial areas, the strains which developed typically yellowish-green or bluish-green or gray green shades, are described and separated into species. But in the cases where the individual conidia are not strongly colored, it sometimes happens that even expertness and experience make it rather difficult to determine whether the color is yellowish-green, bluish-green, or a dull gray-green shade.

Therefore the author can not give complete support to the separation of series as described by Raper, Thom and Fennell (1949), based upon this character only.

Many strains isolated from natural sources in this study differ in a greater or lesser degree from the original description of the species, and few strains developed the same characters described by earlier investigators.

The character of conidia color thus is somewhat useful for the separation of a few series and species, but it is not adequate to be used in separation of species or strains which have very similar shades.

(7) Exudate.

In the strains of *P. chrysogenum* Thom, *P. citreo-viride* Biourge and *P.*

vinaceum Gilman and Abbott the conspicuous transpiration of fluid on surface of growing colonies was seen. Some species or strains do not exude fluid conspicuously, and some, never. The formation of fluid differs among individual species or strains. The character is not recognized as a important basis for classification, except that it is useful as a secondary criterion for the separation of the *P. chrysogenum* series, which produces a yellow pigmented exudate.

(8) Colony reverse and pigmentation of substratum.

Each strain or species developed a characteristic color in the submerged mycelium when grown on agar.

For example, each strain of the *P. purpurogenum* series showed reddish pigmentation, and some species diffused considerable reddish pigment into the surrounding agar; others seldom diffused any pigment and could, on this basis, be separated.

The reverse of the strains or species which were assigned to the *P. herquei* series showed greenish or greenish-brown shades.

In the *P. chrysogenum* series, the colony reverse and surrounding agar developed a yellow pigmentation in some species, but others seldom developed any color. Of course, this basis of classification is known to change with changes of culture conditions, especially in the composition of the medium. In many strains which were isolated from natural sources or which had been kept on artificial medium for many years, the characteristic pigmentation of individual strains developed slower or faster in the same medium and under the same conditions when they were induced to vary or to mutate by artificial treatment. For example, FAT 12 and 30, which were assigned to *P. frequentans* Westling, were reported by Sakaguchi (1930) as *Citromyces*. The texture degenerated into the funiculose type, but the reverse and surrounding agar still developed the characteristic colors of the species after about twenty-five years.

Strains FAT 14 and 15 of *P. spinulosum* Thom, and FAT 13 of *P. purpurrescens* (Sopp) Raper, Thom and Fennell, behave in the same way.

Kondo (1947) found that the colony reverse and the surrounding agar of FAT 1306 developed greenish colors or shades after ten or more continuous inoculations on Bouillon agar. But this strain was observed to develop greenish and reddish shades after one generation on Czapek agar, and only reddish shades after two or more generations on Czapek agar. The strain was assigned to *P. purpurogenum* Stoll.

Strains which degenerated in to yeast type, sterile type or irregular texture formation type, slowly developed pigmentation of the colony reverse and the surrounding agar, but only after about 20 days.

The pigmentless mutation of the penicillin-producing strain Q 176, which was obtained several times by ultraviolet, X-ray or chemical reagents gives warning to investigators to re-examine the "important character" of pigmentation.

In this study no strains were found to lose their characteristic pigmentatation after isolation. It was observed that the strains which develop strong pigmentation on slants sometimes develop weak pigmentation on agar plates, but the strong pigmentation was recovered after transfer to slants once again.

In these cases the pigmentation on slants usually was of the characteristic color but somewhat delayed, and changes occured only within the related shades. The error in using this basis of classification is believed to be very slight compared with the errors in the other criteria.

Thus, this character is useful for classification and is considered an important basis which can be determined easily.

(9) Conidial chains.

The form and length of conidial chains is characteristic of individual strains. The simple observation of conidial chains sometimes suggests the species, as, for example: the long columnar form of *P. frequentans* Westling; the columnar form divided into three or four of *P. citrinum* Thom; the divergent form of the *P. janthinellum* series; and the tangled or loosely parallel form of *P. herquei* Bainier and Sartory.

In many *Penicillia* the conidial chain is not easily destroyed by slight taps, except after long incubation. The conidial chains of P. *crustosum* Thom easily break away with slight taps. Those of *P. oxalicum* Currie and Thom easily break away after about one week incubation. The character of form of conidial chains in separating the *P. janthinellum* and the *P. canescens* series by Raper, Thom and Fennell (1949) and was considered to be important in the classification of species.

In this study the form and length of conidial chains of colonies on petridishes and slants were carefully investigated; the chains were found to be usually somewhat longer on slants than on petridishes, but the form was quite similar. The author observed in older cultures a tendency to develop undeteminable forms, but all of the strains which were newly isolated from natural sources usually produced a characteristic form. Thus, although some natural variation is found, there is sufficient similarity of form within strains to make this character useful in separating species.

(10) Conidia.

A. Form: Westling (1912) described that the character of conidial form was useful for separating sections in *Eupenicillium*. According to Sopp (1912), Biourge (1923) and Thom (1930), it was not useful for sections or series, but was useful for separating species.

Raper, Thom and Fennell (194) used conidial form for the separation of series in the Monoverticillata and species in series; the character was considered to be important in classification.

In this study, the distribution of the strains of globosa form and elliptical form is shown in Table 2. Those strains in which the conidia were of globose form when young and changed to elliptical form when mature were

Table 2. Distribution of conidia according to size.

A. Globose type.

Section and Subsection	−2.2 μ	−2.4 μ	−2.6 μ	−2.8 μ	−3.0 μ	−3.2 μ	−3.4 μ	−3.6 μ	−3.8 μ	−4.0 μ	−4.2 μ	−4.4 μ	−4.6 μ	−4.8 μ	−5.0 μ
Monoverticillata	2	3	11	3	7	7	4	10	10	2	0	2	3	0	1
Asymmetrica Divaricata	0	0	0	2	2	3	1	1	1	0	0	0	0	0	0
Asymmetrica Velutina	0	0	18	11	4	18	20	4	13	0	0	5	4	0	2
Asymmetrica Fasciculata	0	0	0	0	0	3	2	1	13	3	15	14	0	0	0
Biverticillata Symmetrica	0	0	1	0	0	1	0	1	0	0	0	6	2	0	0

B. Elliptical type. (long axis)

Section and Subsection	−2.6 μ	−2.8 μ	−3.0 μ	−3.2 μ	−3.4 μ	−3.6 μ	−3.8 μ	−4.0 μ	−4.2 μ	−4.4 μ	−4.6 μ	−4.8 μ	−5.0 μ	−5.2 μ	−5.4 μ	−5.6 μ	−5.8 μ	−6.0 μ	−9.5 μ
Monoverticillata	0	1	10	18	6	3	13	4	0	4	0	1	1	0	0	0	0	1	0
Asymmetrica Divaricata	0	0	0	5	1	15	31	0	3	0	0	0	0	0	0	0	0	0	0
Asymmetrica Velutina	0	2	8	3	6	2	16	10	3	3	0	0	4	0	7	1	0	0	1
Asymmetrica Fasciculata	0	0	0	0	0	2	10	0	7	3	8	1	1	0	0	0	0	0	0
Biverticillata Symmetrica	1	1	0	0	9	5	38	15	2	25	0	0	0	0	0	0	0	0	0
Polyverticillata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

not included here. Raper, Thom and Fennell (1949) described that the conidial form of the strains of *P. purpurrescens* (Sopp) Raper, Thom and Fennell, *P. lividum* Westling, *P. phoeniceum* van Beyma, *P. humuli* van Beyma, *P. stoloniferum* Thom, *P. viridicatum* Westling, and *P. palitans* Westling is elliptical at first, but becomes subglobose to globose when mature. As described by Thom (1930) and Raper, Thom and Fennell (1949), every conidium theoretically is of cylindrical form when cut off in the apex of the sterigmata.

In this study, the strains of *P. digitatum* Saccado var. *latum* Abe, *P. capsulatum* Raper and Fennell, *P. italicum* Wehmer were found to retain the cylindrical form.

Many conidia in the Biverticillata-Symmetrica group developed as long cylindrical segments of typically small diameter which swelled in the center and became fusiform or elliptical in the course of time.

Eventually globose conidia are formed, and it appears that this type of phenomenon is found when the length of the segments is somewhat longer than the diameter of cells.

In the determination of conidial form some difficulty was found in the relation of the position of the long axis of elliptical conidia to the microscope, in distinguishing between elliptical and ovate forms, between ovate and subglobose forms, etc., but these difficulties may be overcome when experience is acquired by careful observation of thousands of conidia.

In this study, no change of form occured during preservation, even in degeneration types after a long time of preservation. Therefore, the character is useful in classification for separating series, sections and species.

B. Size.

The distribution of strains used in this study according to size is shown in Table 2, distribution curve of both the elliptical and globose forms are shown in Figs. 1 to 4.

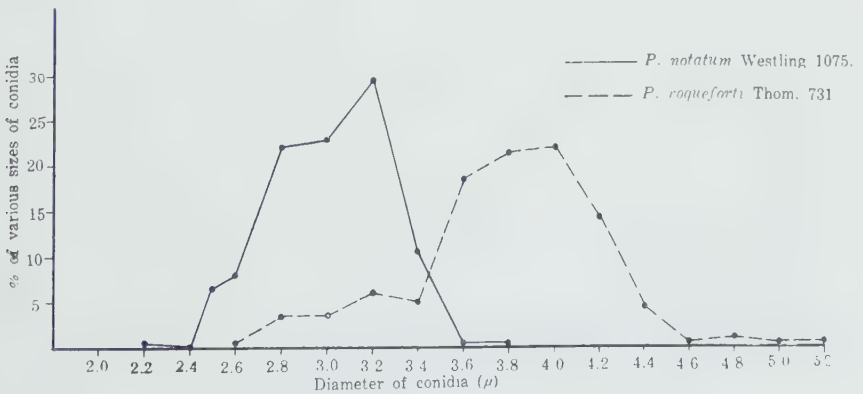

Fig. 1. Distribution curves of size (diameter) of conidia.

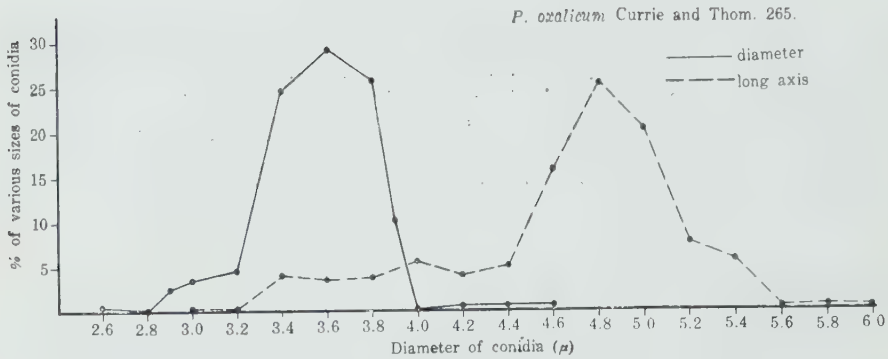

Fig. 2. Distribution curves of size of conidia.

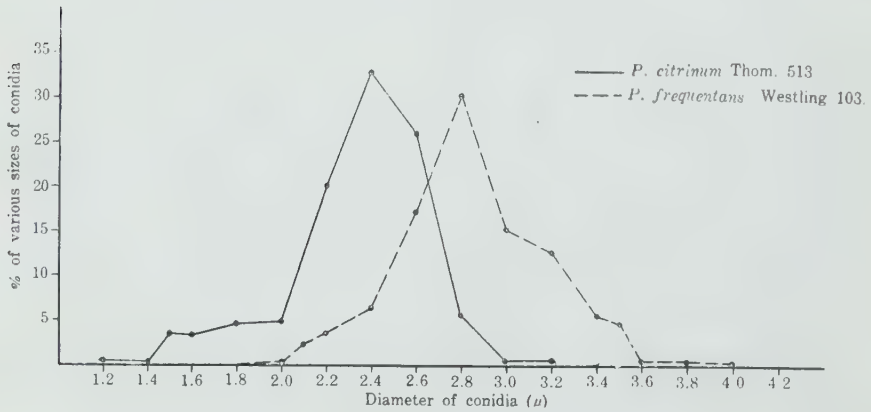

Fig. 3. Distribution curves of size (dimeter) of conidia.

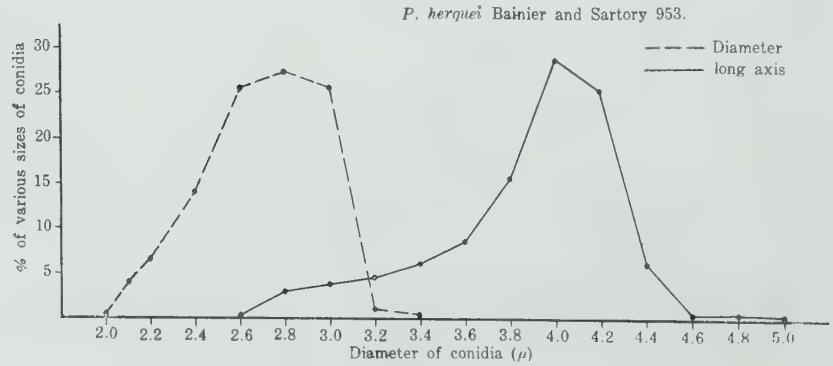

Fig. 4. Distribution curves of size of conidia.

Westling (1912) attached importance to the size of the conidia, and used this character in separating the subsections in *Eupenicillium*.

Biourge (1923), and Thom (1930) used conidial size to separate subsections in the Fragilia or Velutina-elliptical-magna in the Asymmetrica, and Raper, Thom and Fennell (1949) used it in the separation of series in the *P. oxalicum* and the other series in the Velutina subsection of the Asymmetrica.

Precise conidium size may obtained from averaging the dimensions of cells, as described in many reports.

In this study, the size limits of each strain differed somewhat, and each species usually had characteristic conidial dimensions. A very small number of enlarged cells were observed. These many represent, in some cases, conidia in the early stage of germination. In other cases, they have been shown to arise from an interruption of normal septation at the tip of the sterigma in such a way that the material normally going into two or more conidia becomes enclosed within a single cell wall. In many reports, species which show a fluctuation producing larger, conidia, were described.

Raper, Thom and Fennell (1949) described that *P. variable* Sopp had great variablity in size. Corda (1939) reported that the oldest, or end, conidium and the second-oldest conidium in chains in the *P. fiberi* species, were larger than the others. Biourge reported the "Phenomenon of Corda" for a few species, and Thom (1930) and Swift (1935) observed the same phenomenon; Raper, and Fennell (1948), in their description of *P. levitum*, have likewise noted that the terminal conidium is often substantially larger than the other cells in the same chain.

The character of size is not useful in separating species or varieties in which the difference is very small, but it is useful in separating species or varieties in which the difference larger enough to permit certain identification.

The author has found that the range of size of conidia in strains or species which were isolated from natural sources is characteristic and constant. The character is, therefore, of great importance in the determination of species.

(C. Marking of conidia.

The description of smooth walls in previous reports make no problem, but, the descriptions of roughened walls have been variously expressed as follows: echinulate, verruculose, granular, tuberculate, punctate, spinulosity, definitely rough, finely rough, etc. as well as, for slightly roughened walls, delicately, somewhat, more or less, faintly, faint trace, etc.

P. frequentans Westling and *P. fellutaueum* Biourge were described Raper, Thom and Fennell's classification, as smooth or finely roughened; in this study, however, strains having finely roughened conidia were not found.

In *P. phoeniceum* van Beyma previously classified as having smooth or granular walls, granular walled conidia were not observed. *P. multicolor* G.-M. and P. was said to have finely roughened walls, but in this study we find only smooth or slightly roughened walls.

As the character of the conidial walls did not change or show any fluctuation during a long preservation period, this criterion was carefully investigated, and electron microscopy was used to examine many strains in this study.

The character is considered useful in separating series or species and is and important basis for classification.

The distribution of conidial markings in all strains used in this study is shown Table 3.

Table 3. Distribution of the markings of conidia and conidiophores.

Section and Subsections	CONIDIA				CONIDIOPHORE		
	Smooth or nearly so	Slightly roughened	Spinulose	Echinulate & Granular	Smooth or nearly so	Slightly roughened	Punctate & Granular
Monoveticillata	100	4	8	15	111	6	10
Asymmetrica Divaricata	32	12	7	14	20	0	45
Asymmetrica Velutina	157	0	6	2	137	5	23
Asymmetrica Fasciculata	78	0	1	3	16	0	67
Biverticillata-Symmetrica	80	8	0	19	68	8	31
Polyverticillata	1	0	0	0	1	0	0

(11) Sterigmata.

The characters of the sterigmata to be noted are usual number, arrangement, dimension, length, form and marking.

Each character is important or neccessary for classifying species or strains.

a. Usual number and arrangement.

As described by Raper, Thom and Fennell (1949), the first sterigma in a verticil is a terminal cell which is to be transformed into a spore-producing organ; the second pushes out from the cell below the bases of the first, and successive sterigmata but out to form a whirl, verticil or cluster, on the apex of the main axis or some secondary branch thereof.

The usual number and arrangement of sterigmata were delimited for each strain or species, and each had a somewhat characteristic range.

Many strains in the Monoverticillata have 6 to 10 clusters: *P. frequentans* Westling, FAT 12 and 30, *P. sclerotiorum* van Beyma, FAT 1181, *P. multicolor* G.-M. and p. FAT 1051, *P. lilacino-echinulatum* Abe, FAT 84, *P. chermesinum* Biourge, FAT 1287, etc., usually had 6 to 14 or 15, a large number for the *Penicillia*. In this last strain, moreover, the outermost sterigmata of a cluster were incurved.

Most strains of the Asymmetrica had a usual number of 4 to 6 or 8,

but *P. citrinum* Thom and *P. steckii* Zaleskii occasionally had about 10 clusters.

P. cyaneo-fulvum Biourge, FAT 1130, 539, *P. atramentosum* Thom, FAT 1284, *P. digitatum* Saccardo var. *latum* Abe, FAT 605, *P. claviforme* Bainier, FAT 1162, 1163 and 1266, *P. clavigerum* Demelius, FAT 1161, *P. piscarium* Westling, FAT 905, etc. usually had 2 to 4 or 5 clusters of sterigmata. Many species or varieties in the Biverticillata-Symmetrica had 3 to 6 or 8 clusters, and only *P. herquei* Bainier and Sartory showed a usual number of 6 to 9. *P. verrucutosum* Peyonel, FAT 301, *P. varians* Smith, FAT 1209 and 380, *P. rugulosum* Thom, FAT 322 and 375, *P. albicans* Bainier, FAT 1316, etc. usually had 3 to 5 cluster, while. Thus we see that, although each strain had characteristic numbers, no correlation that would permit the strains to be grouped in sections or subsections was observed.

The sterigma are arranged in various forms, as follows: compact form, as seen in *P. frequentans* Westling, *P. notatum* Westling, *P. chrysogenum* Thom, *P. stoloniferum* Thom, and *P. paxilli* Bainier; parallel form, in *P. purpurogenum* Stoll and *P. funiculosum* Thom and *P. lividum* Westling; loosely parallel or divergent form, in *P. multicolor* G.-M. and P., FAT 1051, 124; loosely columnar or somewhat divergent form, in *P. herquei* Bainier and Sartory, FAT 951, 958, 651, 309, 1205, 953, 957, 702, 264 and 1028; loosely divergent form in *P. piscarium* Westling, FAT 711, 881, and 905, *P. janthinellum* Biourge, FAT 909, 1097, 680, 1101, 900, 1102, 870, 861, 875 and 901, etc.; somewhat dipergent form, in *P. nigricans* Thom var. *sulfuratum* Abe, FAT 536, *P. melinii* Thom, FAT 581 and 992, etc.

The character of the arrangement of sterigmata was somewhat different from species to species, but occasionally an intermediate type was recognized.

The typical forms are usuful in separating some species or varieties, but, this character is not useful in the exact separation of all species or varieties because of the intermediate types; it can be used as a sub-basis for classification.

(b. Diameters.

The distribution of sizes of sterigmata of larger diameters is shown in Table 4. Most strains of the *Penicillia* have sterigmata from 2.0 to 4.0 μ in size. Sterigmata of about 1.8 μ are produced by *P. chermesinum* Biourge, FAT 1287 and *P. citreo-viride* Biourge, FAT 569, 326; of 2.0 μ, by *P. rubrum* Stoll, FAT 1145; in the Asymmetrica, there is only *P. digitatum* Saccardo var. *latum* Abe, FAT 605 with sterigmata over 4.0 μ. The strains having sterigmata over 3.5 μ i the Monoverticillata are *P. multicolor* G.-M. and P., FAT 125, *P. frequentans* Westling, FAT 103, 632, 627, 1254, 1256 and 323, *P. implicatum* Biourge, FAT 825, 1218, 1220, 977 and 137, *P. spinulosum* Thom, FAT 1137, *P. trzebiuskii* Zaleski var. *magnum* Sakaguchi and Abe, FAT 24. The strains showing sterigmata over 3.5 μ in the Velutina subsection, are *P. roqueforti* Thom, FAT 731 and 733, *P. pseudo-casei* Abe, FAT 317 and 315

Table 4. Distribution of larger diameter of sterigmata.

Section or Subsection	−1.8 μ	−2.0 μ	−2.2 μ	−2.4 μ	−2.6 μ	−2.8 μ	−3.0 μ	−3.2 μ	−3.4 μ	−3.6 μ	−3.8 μ	−4.0 μ	−4.2 μ	−4.5 μ
Monoverticillata	3	0	10	11	21	8	23	28	9	10	3	1	0	0
Asymmetrica Divaricata	0	0	0	3	41	16	4	0	1	0	0	0	0	0
Asymmetrica Velutina	0	0	0	10	44	33	24	12	25	4	4	7	1	1
Asymmetrica Fasciculata	0	0	0	0	4	3	16	28	9	16	7	0	0	0
Biverticillata-Symmetrica	0	1	1	9	13	33	15	21	0	10	0	3	0	0
Polyverticillata	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Table 5. Distribution of larger length of sterigmata.

Section and Subsection	−5.0 μ	−6.0 μ	−7.0 μ	−8.0 μ	−9.0 μ	−10.0 μ	−11.0 μ	−12.0 μ	−13.0 μ	−14.0 μ	−15.0 μ	−16.0 μ	−17.0 μ	−18.0 μ	−29.0 μ
Monoverticillata	1	0	1	2	9	26	9	18	39	12	3	5	0	2	0
Asymmetrica Divaricata	0	0	0	1	5	7	22	15	13	1	0	1	0	0	0
Asymmetrica Velutina	0	0	0	0	7	46	41	35	19	2	9	4	0	1	1
Asymmetrica Fasciculata	0	0	2	0	1	8	5	43	23	1	0	0	0	0	0
Biverticillata-Symmetrica	0	0	0	0	0	3	11	28	17	28	15	0	3	1	0
Polyverticillata	0	0	0	0	0	0	0	0	1	0	0	0	0	or (1)	0

P. oxalicum Currie and Thom, FAT 265, 258, 630, 1134, 834, 835, 1026, 1180, 1119, 524 and 160, etc.

The strains having sterigmata over 3.5 μ in the Fasciculata subsection, are *P. olivino-viride* Biourge, FAT 633, 572, 634, 1009, 373, 997 and 987, *P. palitans* Westling, FAT 985, 838, *P. viridicatum* Westling, FAT 1273, *P. aurantio-virens* Biourge, FAT 1226, 1225, 1118, 334, 836 and 1297, *P. crustosum* Thom, FAT 584, 593 and 589, *P.italicum* Wehmer, FAT 774, *P. cyclopium* Westling var. *echinulatum* Raper and Fennell, FAT 987, etc.

Some strains with sterigmata over 3.5 μ in the Biverticillata-Symmetrica, are *P. purpurogenum* Stoll, FAT 1073, *P. herquei* Bainier and Sartory, FAT 951, 958, 651, 309, 1205, 953 and 957, *P. variable* Sopp, FAT 1175 and 942, etc.

This character of the size of sterigmata is not used for grouping species or varieties, however, because the strains are too similar.

It is somewhat useful for separating species or varieties. Other investigators have not attached much importance of this character.

c. Length.

The distribution of sizes among longer sterigmata in shown in Table 5.

In the Monoverticillata, many strains measured between 8.1 and 14.0 μ; those which measured less than 8.0 μ are as follows: *P. restrictum* Gilman and Abbott, FAT 779, 3.7 to 5.0 μ, *P. lilacino-echinulatum* Abe, FAT 84, 5.0 to 7.0 μ, *P. fusco-flavum* Abe, FAT 1081, 6.2 to 7.5 μ, and *P. velutinum* van Beyma, FAT 891, 6.2 to 8.0 μ.

The strains measuring more than 15.0 μ are as follows: *P. multicolor* G.-M. and P., FAT 125, 11.2 to 17.5 μ, *P. trzebinskii* Zaleski var. *magnum* Sakaguchi and Abe, FAT 24, 14 to 18 μ, *P. pheoniceum* van Beyma, FAT 1292, 12.5 to 16.0 μ, *P. implicatum* Biourge, FAT 137, 13.0 to 16.0 μ or FAT 977, 10.0 to 15.0 μ, *P. adamentzioides* Abe, FAT 1301 and 1302, 8.7 to 10.6 or 15.6 μ, *P. terlikowskii* Zaleski, FAT 766, 9.3 to 15.6 μ, *P. lividum* Westling, FAT 877, 8.1 to 12.5 or 15.0 μ, *P. trzebinskii* Zaleski, FAT 631, 8.7 to 10.9 to 14.0 μ.

In the Divaricata subsestion, all strains fell in the size range between 8.1 and 14.0 μ, except *P. nigricans* Thom, FAT 948, which measured 6.2 to 7.5 μ.

In addition, all strains of the Velutina subsection of the Asymmetrica were between 8.1 and 14.0 μ, except *P. oxalicum* Currie and Thom, FAT 1180, 1119, 160, and 524 which measured 9.11 to 14.8 μ, FAT 835 and 1026, 9.8 to 15.0 μ, FAT 265, 630 and 1134, 9.8 to 15.6 μ, *P. pseudo-casei* Abe, FAT 317 and 315, 10.6 to 14.3 μ, and *P. digitatum* Saccardo var. *latum* Abe, FAT 605, 10.6 to 18.0 μ.

In the Fasciculata of the Asymmetrica, all strains measured between 8.1 and 14.0 μ except *P. urticae* Bainier, FAT 1314 and 1315 which was 5.0 to 6.3 μ.

In the Biverticillata-Symmetrica, all strains were between 9.1 and 15.0 μ,

somewhat longer than the others, except for *P. varians* Smith, FAT 379, and 380, 9.8 to 13.0 or 17.0 μ, *P. variable* Sopp, FAT 1175 and 942, 12.1 to 17.0 μ, *P. purpurogenum* Stoll, FAT 377, which measured 11.2 to 17.5 μ.

No large differences of this character can be recognized between sections and subsections, and most strains were shown to measure 8.1 to 14.0 or 15.0 μ.

The strains outside these dimensions are described above. Only Raper, Thom and Fennel (1949) among previou investigators hape used this criterion and it they separated the *P. urticae* series from the others in the Fasciculata subsection of the Asymmetrica; in this case the character has proved useful.

However its use is limited to separating species in a few cases and it cannot be used in grouping series.

As Abe, Shiga and and Nakano (1952) and Komatsu and Abe (1953) reported, strains whose spores were treated with ultra-violet irradiation showed shorter, or longer sterigmata than normal. But, strains which were isolated from natural sources did not show any variation from their fixed range of lengths, and the character remained constant in each strain.

No strains were found to have exactly the same lengths as given in other descriptions, and in a few strains a somewhat larger difference than described was found.

d. Form of sterigmata.

Raper, Thom and Fennell (1949) accepted in general the types of form: proposed by Thom (1930). These were acute, lanceolate, acuminate, beak-like, the *Scopulariopsis* type, the *paecilomyces* type and varieties of these types. These authors attached importance to this character in their classification of the *Penicillia* and related genera.

In this study, many strains of the Monoverticillata and the Asymmetrica except in the Divaricata subsection, were found to be of the acute, or nearly acute type. The strains in the Monovertillata that produced varietal forms were as follows: in *P. chermesinum* Biourge, FAT 1287, tips were narrow; in *P. vinaceum* Gilman and Abbott FAT 1291 apices were narrow; *P. phoeniceum* van Beyma, FAT 1292 had gradually tapered tips; and in *P. sclerotiorum* van Beyma, FAT 1131, P. thomii Maire var. flavescens Abe, FAT 340 and *P. cinnamopurpureum* Abe, FAT 362 and 363, tips were somewhat narrow.

In the Velutina of the Asymmetrica, eleven strains of *P. oxalicum* Currie and Thom were of acute but somewhat tapered type, and *P. atramentosum* Thom, FAT 1284, and *P. digitatum* Saccardo var. *latum* Abe, FAT 605 were of similar form.

In the Fasciculata subsection, *P. martensii* Biourge, FAT 305 was of the acute type but the apices were somewhat narrow; and *P. clavigerum* Demelius, FAT 1161 was of gradually tapered form. In the Divaricata subsection, the character of being abruptly tapered to narrow conidium tubes, characteristic of the *P. janthinellum* series that Raper, Thom and Fennell (1949) described, was observed, was observed in most strains. In other

words, all the strains of this group were shown to have abruptly tapered, gradually narrowed tips, except *P. nigricans* Thom, FAT 948, *P. nigricans* Thom var. *sulfuratum* Abe, FAT 536, and *P. jensenii* Zalski, FAT 770, which were of the acute type.

In the Biverticillata Symmetrica, most strains were shown to be of the lanceolate type and the acuminate type, as pointed out by Raper, Thom and Fennell (1949); but exceptionally, the strains of *P. herquei* Bainier and Sartory and *P. paraherquei* Abe were of abruptly tapered and narrow beak-like types, while *P. estinogenum* Komatsu and Abe had narrow tips. FAT 1316 of *P. albicans* Bainier in Polyverticillata was shown to have the tips somewhat narrowed.

Therefore, this character is cosidered important as a basis for classification in assigning species or varieties and in separating related genera and sections. In particular, it is necessary to attach importance to this character in separating thn Biverticillata-Symmetrica from the Asymmetrica; if this character is neglected, the determination of species in the *P. paxilli*, and *P. citrinum* and *P. steckii*, etc., groups may be misclassified with the Biverticillata-Symmetrica.

To separate sections on this basis alone is impossible, but it is assumed to follow the character of penicillus pattern in importance in separating species.

e. Marking.

The strains having sterigmata with roughened walls were *P. palitans* Westling var. *echinoconidum* Abe FAT 848 and 1019 in the Fasciculata subsection, which usually has granular walls, and *P. estinogenum* Komatsu and Abe, FAT 1196 and 1195 in the Biverticillata-Symmetrica which usually has silghtly roughened walls.

In *P. canescens* Sopp FAT 832 and *P. casei* Staub var. *compactum* Abe, FAT 1276, both smooth walled and punctate walled sterigmata were found. Most other strains of *Penicillum* have or nearly smooth walls.

In former descriptions of *Penicillium* this character was not described and was not used for classifications.

In this study, the character is not condiered very useful for classification, but it is somewhat useful in separating species conspicuously roughened walls.

12) Metulae.

The metulae are the cells which are found in the penicillus of the Biverticillata or the Polyverticillate form, and their arrangement, form and pattern are the points studies by many investigators.

The differences of pattern or form between the Biverticillata-Symmetrica, the Biverticillata-Asymmetrica and the Divaricata subsection which Thom (1930) and Raper, Thom and Fennell (1949) described, were used in this study. A similarity in form was found between *P. paxilli* Bainier, the *P. citrinum*

series and the *P. herquei* series, but these species or series can be separated by other criteria.

The characters of metulae are important as they are characteristic in strains which are newly isolated from natural sources. But, on the other hand, these characters occasionally become irregular in strains which have been kept for many years. For example, the strains of the Biverticillata-Symmetrica are not diffcult to pick out because of their typical lanceolate or acuminate sterigmata, but in some strains of the Biverticillata-Asymmetrica a tendency to transform to the divaricate form is occasionally recognized. Furthermore, in strains producing sparse conidial structures in spite of repeated monospore culture, or in strains the texture of which becomes irregular and whose sporulation is delayed, other types of observation are neccessary.

Therefore in this study, all the irregular type strains which had been kept for a long time had to be omitted from this screening.

Although it is true that this character suffers variation or mutation or mutation in strains kept too long, it is still condiered sufficiently characteristic of sections, series or species to be used as a subbasis for classification.

The other characters of the metulae, including usual number, dimensions of the apices, diameter, length, marking, etc. were shown to be characteristic only of individual strains, species or varieties.

In separating strains of the *P. brevi-compactum* series, however, these characters are important. The length of the metulae in strains of the Divaricata is important in separating strains of the *P. citrinum* series, *P. funiculosum* and the *P. purpurogenum* series, the usual number, arrangement and length are also important.

(13) Branches.

The larger penicilli of many strains of the Biverticillata-Asymetrica have one, two, or more branches. Penicilli in the Biverticillata-Symmetrica generally have no branches, but in some strains a branch is observed at the level of the metulae on the main conidiophore axis, making terminal verticil. Branches were evident on the penicilli of the Polyverticillata.

The arrangement of branches of the penicilli is important for classification in the Asymmetrica subsection.

The characters of dimensions of the apices, diameter, length, markings, were not considered important by other investigatars, and in this study, these characters are not recognized as base for classification.

(14) Conidiophores.

a. Origin.

The conidiophores are simple, unbranched or variously branched. They arise directly from the vegetal hyphae, either submserged or aerial.

In the former case, they are single or they form a cluster, fascicle or coremium. Determination of the pattern is necessary as this character is important in determinating the texture.

b. Foot cells.

Foot cells were shown by Thom and Church (1926) and Thom and Raper (1945) to be a characteristic of the *Aspergilli*; they were also found in *P. varians* Smith and *P. pallium* Smith. In this study, the author observed them in *P. varians* Smith, but in no other *Penicillia*. Therefore as this seems to be characteristic of one species only, it not useful as a basis for classification.

c. Apices of conidiophores.

The distribution of sizes in conidiophores of large diameter in this study is shown Table 6. The range of the distribution in the Monoverticillata is the broadest in the *Penicillia*. The range was from 2.6 to 9.0 μ, the species measuring more than 7.6 μ including: *P. frequentans* Westling, FAT 1032, 826 and 323, *P. aurantio-violacem* Biourge, FAT 649, *P. spinulosum* Thom, FAT 1137, *P. implicatum* Biourage, FAT 137, 1299, etc., and the species having apices less than 3.0 μ long being: *P. cyaneum* Bioarge, FAT 741, and *P. restrictum* Gilman and Abbott, FAT 779. In the Divaricata subsection of the Asymmetrica, strains having larger dimensions were not observed, and in most strains the length was less than 5.0 μ. The character of dimension of the apices is not useful in grouping species because they are too similar in size, and rather large differences are found between strains of the same species. Some similar to *Aspergillus* were found in strains of the Monoverticillata, but these differed in each strain. In other sections or subsections, no characteristic form was seen.

Therefore, this character is a subbasis of classification only, and is somewhat useful only in separating some species.

d. Diameters.

The distribution of the diameters of all the strains in this study is shown in Table 7. Strains measuring more than 7.0 μ, were not found, and almost all the strains of the Monoverticillata and the Divaricata subsections of the Asymmetrica wers less than 4.5 μ in diameter. Strains measuring less than 2.0 μ were found only among the Monoverticillata, as follows: *P. fellutanum* Biourge var. *nigro-castaneum* Abe, FAT 623 and 624; *P. terlikowskii* Zaleski, FAT 1290, *P. lilacino echinulatum* Abe, FAT 84, *P. vinaceum* Gilman and Abbott, FAT 1291.

In the Velutina subsection of the Asymmetrica, the distribution of diameters was found to be from 2.6 to 7.0 μ. Strains measuring more than 6.1 μ are as follow; *P. notatum* Westling, FAT 350, 547 and 545, *P. roqueforti* Thom, FAT 731, and 733, *P. casei* Staub var. *compactum* Abe, FAT 1276.

In the Fasciculata subsection of the Asymmetrica, the distribution of diameter was shown to be 4.1 to 6.5 μ, and the only strains measuring over 6.1 μ were *P. puberulum* Bainier, FAT 1304 and *P. aurantio-virens* Biourge, FAT 887. In the Biverticillata-Symmetrica, the distribution of diameters was shown to be from 2.6 to 5.5 μ; the only strain having a diameter of less

Table 6. Distribution of sizes of conidiophores (diameter of apices).

Section and Subsection	−3.0 μ	−3.5 μ	−4.0 μ	−4.5 μ	−5.0 μ	−5.5 μ	−6.0 μ	−6.5 μ	−7.0 μ	−7.5 μ	−8.0 μ	−8.5 μ	−9.0 μ
Monoverticillata	2	15	17	10	19	1	5	24	19	8	1	5	1
Asymmetrica Divaricata	0	2	14	27	20	0	0	2	0	0	0	0	0
Asymmetrica Velutina	0	0	1	50	28	11	25	33	8	9	0	0	0
Asymmetrica Fasciculata	0	0	0	2	1	17	40	22	1	0	0	0	0
Biverticillata-Symmetrica	0	2	7	38	38	2	14	2	3	0	0	0	0
Polyverticillata	0	0	0	0	0	0	1	0	0	0	0	0	0

Table 7. Distribution of sizes of conidiophores (diameter).

Section and Subsection	−2.0 μ	−2.5 μ	−3.0 μ	−3.5 μ	−4.0 μ	−4.5 μ	−5.0 μ	−5.5 μ	−6.0 μ	−6.5 μ	−7.0 μ
Monoverticillata	5	35	17	33	82	9	0	0	0	0	0
Asymmetrica Divaricata	0	0	12	23	17	11	2	0	0	0	0
Asymmetrica Velutina	0	0	13	31	38	17	30	11	19	4	2
Asymmetrica Fasciculata	0	0	0	0	0	2	20	34	25	2	0
Biverticillata-Symmetrica	0	1	16	33	31	9	7	10	0	0	0
Polyverticillata	0	0	0	0	0	0	1	0	0	0	0

than 2.5 μ *P. rubrum* Stoll, FAT 1145; the strains having diameters of more than 5.1 μ were *P. herquei* Bainier and Sartory, FAT 951, 958, 651, 309 and 1205, and *P. estinogeuum* Komatsu and Abe, FAT 1196 and 1195. One strain in the Polyverticillata measured about 5.0 μ. The character was used by Raper, Thom and Fennel (1949) only to separate *P. olsoni* Bainier and Sartory.

No importance was attached to this character by previous investigators, and no characteristic differences were observed between species, with some exceptions. The measurement of diameter of conidiophores, therefore, is of some use and determining species and varieties, but it is only a subbasis for classification of the *Penicillia*.

(e. Length.

The distribution of the length of conidiophores of all strains examined in this study, is shown in Table 8.

Table 8. Distribution of the length of conidiophores.

Section and Subsection	−100 μ	−150 μ	−200 μ	−250 μ	−300 μ	−350 μ	−400 μ
Monoverticillata	36	32	28	7	5	2	10
Asymmetrica Divaricata	0	10	2	2	2	1	7
Asymmetrica Velutina	0	7	39	24	19	19	29
Asymmetrica Fasciculata	0	4	0	1	10	13	38
Biverticillata-Symmetrica	6	20	35	26	12	4	4
Polyverticillata	1	0	0	0	0	0	0

Section and Subsection	−450 μ	−500 μ	−550 μ	−600 μ	−650 μ	−700 μ	−10 mm
Monoverticillata	5	1	0	0	1	0	0
Asymmetrica Divaricata	9	25	0	5	0	2	0
Asymmetrica Velutina	9	11	2	4	0	2	0
Asymmetrica Fasciculata	8	1	0	4	1	2	1
Biverticillata-Symmetrica	0	0	0	0	0	0	0
Polyverticillata	0	0	0	0	0	0	0

The strains having lengths of more than 500 μ were as follows: *P. lividum* Westling, the only one in the Monoverticillata (400 to 640 μ); *P. ochro-chloron* Biourge, FAT 1111, 678, 682, 534 and 906 in the Divaricata subsection (190 to 600 μ); *P. chrysogenum* Thom, FAT 919, 853, 855 and 700, *P. chrysogenum* Thom mut. *flavescens* Takashima, Arima and Abe, FAT 515, and *P. brevi-compactum* Dierckx, FAT 1285 (less than 600 μ);

P. roquefoti Thom, FAT 42, 543 (200 to 700 μ), etc. in the Velutina subsection; in the Fasciculata subsection, *P. crustosum* Thom, FAT 352, 371, *P. urticae* Bainier, FAT 1314 and 1315, *P. claviforme* Bainier, FAT 1266, *P. claviforme* Bainier mut. *candicans* Abe and Ura, FAT 1277, *P. claivforme* Bainier mut. *olivicolor* Abe and Ura, FAT 1278, etc. (less than 700 μ); *P. clavigerum* Demelius, FAT 1161 (2 to 10 mm.), which is exceptionally long for this genus.

In almost all the strains of the Biverticillata-Symmetrica, the length was less than 400 μ, and one strain in the Polyverticillata was less than 100 μ in conidiophore length.

Strains having conidiophores less than 100 μ long were found in the Monoverticillata, as follows: *P. restrictum* Gilman and Abbott, FAT 779, *P. fusco-flavum* Abe, FAT 1081, *P. terlikowski* Zaleski, FAT 1290, *P. lilacino-echinulatum* Abe, FAT 84, *P. vinaceum* Gilman and Abbott, FAT 1291, *P. chermesinum* Biourge, FAT 1287, *P. decumbens* Thom, FAT 599, 602, 603, 604 and 1071, *P. citreo viride* Biourge, FAT 568, 1022, 1176, 1229, 967, 970, 959, 196, 567, 653, 960, 358, 360, 1023, 569 and 326, *P. roseo-purpureum* Diercix, FAT 780 and 1288, *P. capsulatum* Raper and Fennell, FAT 564 and 565, *P. charlesii* Smith var. *rapidum* Abe, FAT 831, and in the Biverticillata-Symmetrica, *P. aculeatum* Raper and Fennel var. *apiculatum* Abe, FAT 645, *P. verruculosum* Peyronel, FAT 1114, 961 and 665, and *P. varians* Smith, FAT 1209 and 949. In the Polyverticillata *P. albicans* Bainier FAT 1316 measured 20 to 100 μ.

This character was used by Thom (1930) and Raper, Thom and Fennell (1949) in separating some species. In this study, it is also used in separating some species, but it is not useful for many species or varieties.

The length of conidiophores showed some variation within strains or species, but usually a characteristic range was found.

Accordingly, this character is useful, but only in separating species in which the differences are clear.

(f. Markings.

The markings of conidiophores are similar to those described previously for conidia. This character was used by Raper, Thom and Fennell (1949) in separating the *P. roqueforti* series and other series in the Velutina subsection of the Asymmetrica, in separating the *P. granulatum* and the *P. claviforme* series in the Fasciculata subsection of the Asymmetrica, and in separating the *P. herquei* and other series in the Biverticillata-Symmetrica. Some species showed smooth walls on Czapek agar but roughened walls on malt agar, as described by Raper, Thom and Fennell (1949), but the character of each strain or species is usually stable under the same conditions.

In this study, conspicuously roughened walls, with protuberances measuring about 0.3 to 1.0 μ, were observed in all strains of *P. roqueforti* Thom, *P. casei* Staub, *P. viridicatum* Westling, *P. olivino-viride* Biourge, *P. cyclo-*

pium Westling, and *P. herquei* Bainier and Sartory, but many other strains of the *Penicillia* had smooth or slightly roughened walls.

As described for conidia previously, conspicuously roughened walls can easily be distinguished from smooth or nearly smooth walls.

The distribution of this character among the strains used in this study is shown in Table 3. It is not considered to be important in species or varieties of the Monoverticillata but it can be used for grouping species in the Biverticillata Symmetrica and the Biverticillata Asmmetrica, and it is useful in separating individual species or varieties.

15) Biochemical characteristics.

1. Rate of growth.
2. Growth on Sakaguchi and Wang agar.
3. Antifungal or antibacterial activity.
4. Color and color change of broth due to changes in pH.
5. Extraction of the pigments of broth with various solvents in acid, neutral and alkaline solution.
6. pH of broth, acidity, and weight of dried mycelia.
7. Color reaction with ferric chloride.
8. Reducing power.
9. Fluorescent substances.
10. Clarification activity (pectin).

The biochemical characteristics listed above were investigated will be described in part 2.

A new classification of the *Penicillia*.

If any one of the morphological base for separation or classification described above is neglected, the correct determination of a species cannot be achieved. We cannot clearly determine the relative importance of each of these criteria, and the order in which they should be applyed to the genus *Penicillium* cannot be decided. The general classification given by Raper, Thom and Fennell (1949), in which Thom's monograph (1930) was revised, was found to be reasonable.

But, within series and species was a number of questionable and unsuitable points were noted, as described above.

In addition the author obtained many strains within fourteen species and thirteen varieties and three mutants, all new.

On the combined bases of morphological character and biochemical characteristics a new classification of the *Penicillia* has been established, which is described in the following sections.

CLASSIFICATION OF THE GENUS *PENICILLIUM*

I. Penicilli consisting of single clusters, or verticils of sterigmata at the tips of fertile hyphae or conidiophores; conidiophores usually unbranched, in some forms irregularly branched but with each brance terminating in a

distinct and separate monoverticillate penicillus.
..... Monoverticillata Section.

1. Colonies producing perithecia or sclerotia.
   A. Colonies producing fertile perithecia but perithecia often ripening late.
      (1. Perithecia firm or sclerotioid at first, ripening from the center outward.
         a. Penicilli monoverticillate or fragmentary .....*P. javanicum* series. (Same as: Raper, Thom and Fennell, A manual of the Penicillia, 127–129. 1949.)
         b. Penicilli typically biverticillate but with monoverticillate structures produced, and with perithecia at first sclerotioid, and ripening late. ..... *P. carpenteless* series.
      (2. Perithecia soft, loose-textured, without a definite or firm outer wall; penicilli commonly fragmentary, often appearing monoverticillate. (Same as: Raper, Thom and Fennell, op. cit., P. 129. 1949.)
   B. Colonies producing sclerotia, often suggestive of young perithecia but never developing an ascogenous stage.
      (I) Penicilli strictly monoverticillata.
         –a. Sclerotia produced upon all substrates, hard, brittle, crushing with difficulty, composed of thick-walled sclerenchyma-like cells. ..... *P. thomii* series.
            1) Colonies on Czapek agar seldom developing dull, dark purple colors in reverse.
               1. Sclerotia colorless or nearly so, borne in small clusters surrounded by conspicuous envelopes of bright orange-red mycelium. ..... *P. sclerotiorum* van Beyma.
               2. Sclerotia in flesh to pink shades, not in clusters and not embeded in masses of orange-red hyphae.
                  a. Colonies typically in gray-green shades, colonies growing restricted. .....*P. thomii* Maire.
                  b. Colonies typically in bright yellow-green shades, colonies growing rather broadly.
                  .....*P. thomii Maire var. flavescens* Abe.
               3. Sclerotia in orange-brown shades, not in clusters, often surrounded by loose network of yellow to orange or light brown mycelium. ..... *P. lapidosum* Raper and Fennell.
            2) Colonies on Czapek agar developing dull, dark purple colors in reverse; sclerotia in light pinkish-brown shades, colonies rather restricted; mycelium in grayish vinaceous or brownish shades. ..... *P. cinnamopurpureum* Abe.
         –b. Sclerotia produced upon some substrata, not on others including Czapek, comparatively soft, composed of pseudo-parenchymatous cells with walls thickened. ..... *P. turbatum* sub-series.

1. Colonies on Czapek agar not developing dull, dark purple colors in reverse, somewhat restricted. .....*P. turbatum* Westling.
2. Colonies on Czapek agar developing dull, dark purple colors in reverse, very restricted. ..... *P. pusillum* Smith.

(2) Penicilli typically biverticillate-asymmetrica. .....*P. raistrickii* series. (in the Divaricata.)

2. Colonies not producing perithecia or sclerotia.

((A. Conidiophores generally unbranched and bearing single, strictly monoverticillate penicilli.

(1. Conidia globose to subglobose. .....*Monoglobosa* series.

A) Conidia conspicuously rough-walled.

1) Colonies generally spreading broadly on most media, growing at 5°C.

1. Conidia conspicuously verruculose or echinulate, reverse in reddish or brownish shades, colonies velutinous. ..... *P. purpurrescens* (Sopp) Raper, Thom and Fennell.
2. Conidia spinulose, reverse in colorless to pale yellow or pale pinkish shades and sometimes in purplish or violet shades, colonies velvety or velutinous or loosely textured. ..... *P. spinulosum* Thom.

2) Colonies growing rather restrictedly upon most media, seldom growing at 5°C.

a. Seldom growing on Sakaguchi & Wang agar.

1. Conidia conspicuously echinulate, reverse in vinaceous lilac to yellow shades, colonies funiculose. ..... *P. lilacino-echinulatum* Abe.

b. Growing on Sakaguchi & Wang agar.

2. Conidia echinulate or granular, conidial area dull gray or smoke gray shades, reverse in dull yellow shades, colonies floccose. ..... *P. restrictum* Gilman and Abbott.
3. Conidia conspicuously echinulate or tubercles, conidial areas olive green becoming brown shades, reverse colorless or nearly so, colonies floccose. .....*P. fuscum* (Sopp) Raper, Thom and Fennell.

B) Conidia smooth or slightly rough-walled. (Spines less than 0.1 μ)

1) Colonies generally spreading broadly on most media.

1. Conidiophores usually more than 100 μ in length, seldom growing Sakaguchi & Wang agar. .....*P. frequentans* Westling.
2. Conidiophores vory short, colonies funiculose. ..... *P. adametzi* Zaleski.

2) Colonies growing rather restrictedly upon most media.

a. Usually growing on Sakaguchi & Wang agar.

1. Colonies quickly developing bright yellow colors in reverse and agar.
   i. Conidial areas light blue-green or yellow green shades, reverse in bright yellow shades throughout. ..... *P. citreo-viride* Biourge.
   ii. Conidial areas pale yellow green shades (approaching Sage Green or Vetiver Green), colonies reverse in orange-brown or citrine brown shades in central area. .... *P. citreo-viride* Biourge var. *aeneum* Abe.
2. Colonies quickly developing deep vinaceous to purple colors in reverse and agar. .....*P. vinaceum* Gilman and Abbott.

b. Seldom growing on Sakaguchi & Wang agar.
1. Vegetative mycelium usually pigmented.
   i. Vegetative mycelium yellow to orange or orange-red, conidiophores mostly more than 60 μ in length, colonies velutinous. .....*P. multicolor* G.-M. and P.
   ii. Vegetative mycelium white to pale vinaceous, conidiophores mostly less than 60 μ in length, colonies subfloccose. .....*P. roseo-purpureum* Dierckx.
2. Vegetative mycelium seldom pigmented, colonies predominantly funiculose. ..... *P. terlikowskii* Zaleski.

(2. Conidia elliptical to ovate or subglobose. .....*Monoelliptica* series.

A. Conidia conspicuously rough-walled; echinulate or verruculose or (tuberculate) walls in electron microscopy.
1) Colonies growing rather rapidly, spreading; colonies growing at 5°C.
1. Conidial areas in blue green or yellow green shades, reverse in deep violet, violet black or dark fuscous shades. ..... *P. trzebinskii* Zaleski.
2. Conidial areas in dull yellow green shades, reverse colorless; conidia usually 4.5 μ or more in length. .....*P. trzebinskii* Zaleski var. *magnum* Sakaguchi and Abe.
3. Conidial areas in blackish green or darkish blue-green shades, reverse in purplish vinaceous or greenish shades, localized; usually strongly vanilla-like odor produced. .....*P. trzebinskianum* Abe.

2) Colonies growing heavily and restrictedly upon most media; seldom growing at 5°C; conidial areas dark yellow green shades, reverse colorless. ..... *P. fusco-flavum* Abe.

B. Conidia smooth or slightly rough-walled. (Spines less than 0.1 μ)
(1) Colonies growing broadly spreading.
a. Growing on Sakaguchi & Wang agar; conidiophores usually more than 350 μ in length.

1. Conidia strongly elliptical; colonies in yellow green becoming olive or citrine drab shades, reverse yellow or flesh shades. .....*P. lividum* Westling.
2. Conidial elliptical to ovate; colonies remaining yellow green in age or tardily becoming light brown in 4 weeks or more, reverse purplish or violet shades becoming yellow shades. .....*P. aurantio-violaceum* Biourge.

b. Seldom growing on Sakaguchi & Wang agar; conidiophores less than 100 μ in length; reverse in vinaceous to reddish shades. .....*P. chermisinum* Biourge.

(2) Colonies growing rather restrictedly upon most media.

a. Colonies usually showing strong pigmentation in reverse and agar.

1) Luxuriantly growing on Sakaguchi & Wang agar; reverse and surrounding agar usually strongly pigmented in bright red violet or purplish shades.....*P. phoeniceum* van Beyma.

2) Seldom growing on Sakaguchi & Wang agar.

1. Seldom growing at 5°C or 37°C; conidial areas in deep blue- or bluish gray- or dark yellow-green shades; reverse in yellow, orange, reddish, sometimes purplish or violet shades; surrounding agar in bright or pale yellow shades. .....*P. implicatum* Biourge.
2. Growing at 37°C, seldom growing at 5°C; conidial areas in bluish gray green shades; reverse and surrounding agar in orange red or red-brown shades. .....*P. sublateritum* Biourge.
3. Growing at 5°C, seldom growing at 37°C; conidial areas in pale yellow green shades; reverse and surrounding agar in orange or orange brown or pale vinaceous shades. .....*P. adametzioides* Abe.

b. Colonies usually showing colorless or slight pigmentation in reverse and agar.

1) Colonies typically velvety or velutinuous; conidial areas in blackish green or dark blue green shades.

1. Luxuriantly growing on Sakaguchi & Wang agar; seldom growing at 37°C; conidial areas blackish yellow green shades, reverse colorless or slightly greenish shades in central areas, localized. .....*P. decumbens* Thom var. *atro-virens* Abe.
2. Seldom growing on Sakaguchi & Wang agar; growing at 37°C; conidial areas in dark blue green shades, reverse usually in brownish red colors in central areas. .....*P. fellutanum* Biourge var. *nigro-castaneum* Abe.

2) Colonies appearing velvety, but usually with surface lightly

floccose; colonies seldom in blackish green or dark blue green colors.

1. Colonies generally loose textured, consisting of a loose network of interlacing hyphae bearing short conidiophores; reverse colorless, becoming slightly pinkish or greenish shades. .....*P. decumbens* Thom.
2. Colonies close textured, tough, leathery, with margin compact but showing stolon-like hyphae; reverse becoming pale vinaceous or pale yellow shades. .....*P. fellutanum* Biourge.

((B. Conidiophores mostly branched, occasionally rebranched, each bearing a terminal monoverticillate penicillus but not arranged as a definite apical verticil of metulae (or branchlets) .....Ramigena series.

1) Conidia definitely elliptical, and with walls smooth or nearly so.

1. Conidia strongly elliptical to narrowly cylindrical (capsule-shape), with ends broad, not pointed.
.....*P. capsulatum* Raper and Fennell.
2. Conidia elliptical and with ends somewhat pointed.
.....*P. cyaneum* (B. and S.) Biourge.

2) Conidia globose, ovate, or slightly elliptical.

A. Colonies growing restrictedly upon most media.

1. Conidia globose to subglobose and with walls delicately roughened, in divergent chains, not forming columns.
.....*P. waksmani* Zaleski.
2. Conidia ovate or slightly elliptical, in parallel chains forming compact columns. .....*P. charlesii* Smith.

B. Colonies growing rapidly upon most media.

1. Conidia globose to subblobose and walls loosely roughened.
.....*P. charlessii* Smith var. *rapidum* Abe.
2. Conidia globose to ovate and with walls conspicuously echinulate or verruculose. .....*P. velutinum* van Beyma.

II. Penicilli characteristically once- or twice-branched below the level of the sterigmata; typically asymmetrical, irregular, or one-sided; sterigmata not lanceolate. .....Asymmetrica Section.

(A. Penicilli characteristically strongly divaricate, with individual elements strongly divergent, often appearing monoverticillate but so arranged as to produce the appearance of a single branched penicillus.
.....Divaricata Sub-section.

(1. Colonies producing perithecia, sclerotia, or masses of thick-walled cells.

a. Colonies producing true perithecia, parenchymatous or sclerotioid throughout; ripening from the center outward and often late.
.....*Carpenteles* series. (Same as: Raper, Thom and Fennell, op. cit., P. 257. 1949.)

b. Colonies producing sclerotia or masses of thick-walled cells, but apparently not developing asci and ascospores at any stage. (Same as: Raper, Thom and Fennell, op. cit., pp. 257–258. 1949.)
.....*P. raistrickii* series.

(2. Colonies not producing perithecia, sclerotia, or masses of thick-walled cells.

(a. Colonies not showing green, gray-green or blue-green with the ripening of conidia.

1. Colonies developing lilac, vinaceous or violaceous shades.
.....*P. lilacinum* series.

1-a. Colony reverse developing vinaceous or purple-red shades.
.....*P. lilacinum* Thom.

1-b. Colony reverse developing bright yellow shades.
.....*Spicaria violacea* Abbott.

2. Colonies developing pinkish-buff to avellaneous shades.
.....*P. humuli* van Beyma.

3. Colonies velvety or nearly so, with conidial areas in tan, cream or near-white shades, never showing green.
.....Natural mutants of many species.

(b. Colonies showing some shades of green, gray, gray-green, or blue-green with the ripening of conidia.

((-1. Penicilli with divaricate character well marked, sterigmata-bearing brsnchlets (metulae) scattered on the conidiophores, or commonly only partly aggregated into true verticils.

-(A. Ripe conidia typically in pale blue-green or gray-green shades and colony reverse often highly colored.

-(1. Conidial chains strongly divergent and becoming tangled in age, not tending to form columns.

-a) Sterigmata abruptly tapered to narrow conidium-bearing tubes; colonies usually not funiculose.
.....*P. janthinellum* series.

1) Conidia elliptical, rough with echinulations arranged in spiral or transverse bands. .....*P. daleae* Zaleski.

2) Conidia smooth or roughened, but with echinulations not arranged in spiral or transverse bands.

a. Colony reverse and vegetative mycelium often strongly colored (orange-red, reddish purple, etc.) in new isolates.
.....*P. janthinellum* Biourge.

b. Colony reverse colorless or in yellow to orange shades, vegetative mycelium colorless or light buff to peach shades.

(1) Conidiophores roughened.

1. Colony reverse colorless or yellow shades; penicilli commonly consisting of a terminal verticil of diver-

gent metulae. .....*P. simplicissimum* (Oud) Thom.

2. Colony reverse near orange shades; penicilli often irregular. .....*P. ochro-chloron* Biourge.

(2) Conidiophores smooth or nearly so.

1. Conidia with conspicuously roughened walls. .....*P. piscarium* Westling.

2. Conidia with smooth or nearly so, walls. .....*P. miczynskii* Zaleski.

-b) Sterigmata not abruptly tapered to conidium-bearing tubes; colonies commonly becoming funiculose. .....*P. godlewskii* Zaleski.

-(2. Conidial chains tending to form columns, at least in young cultures; conidia blobose to subglobose or ovate. .....*P. canescens* series.

1. Colony reverse orange red or deep red shades; conidia globose, with smooth, or nearly so, walls. .....*P. nalgiovensis* Laxa.

2. Colony reverse and surrounding agar deep red shades; conidia ovate, with echinulate or verruculose walls. .....*P. echinulo-nalgiovense* Abe.

3. Colony reverse orange becoming rich brown shades; conidia globose with smooth or slightly roughened walls. .....*P. canescens* Sopp.

4. Colony reverse colorless or in dull peach or yellow shades, not developing dark colors; conidia globose with delicately echinulate walls. .....*P. jenseni* Zaleski.

-(B. Ripe conidia typically in dull gray shades such as steel gray to dark olive gray (Ridgway), globose; colony reverse usually in yellow to deep orange shades. .....*P. nigricans* series.

1) Conidiophore walls smooth or nearly so on all substrata.

A. Conidia strongly aculeate or echinulate.

1. Colonies developing dull to dark gray shades; rather restrictedly. .....*P. nigricans* (Bainier) Thom.

2. Colonies developing dull to gray-green shades; growing rather rapidly. .....*P. nigricans* (Bainier) Thom var. *sulfuratum* Abe.

3. Colonies white or nearly so; light sporulating; floccose. .....*P. albidum* Sopp.

B. Conidia delicately echinulate.....*P. kapuscinskii* Zaleski.

2) Conidiophore walls coarsely roughened, at least on malt agar.

1. Conidia aculeate. .....*P. melinii* Thom.

2. Conidia smooth or nearly so. .....*P. raciborskii* Zaleski.

((-2. Penicilli with divaricata character evident, but tending toward compactly biverticillate with metulae usually borne at a single

level and conidia producing compact columns that are typically divergent. .....*P. citrinum* series.

(B. Penicilli seldom strongly divericate, usually compact, with branches and metulae tending to be parallel rather than divergent.

(1) Colonies typically velvety, with conidiophores arising characteristically from the substratum in a dense even stand.

..... Velutina Sub-section.

(1. Penicilli seldom branched below the level of metulae, with metulae often more or less divergent, seldom growing at 5°C and 37°C, usually growing on Sakaguchi & Wang agar.....*P. citrinum* series.

a. Conidia globose to subglobose.

1. Colonies showing bright yellow to orange-pink shades in exudate or reverse and surrounding agar; penicilli suggesting a symmetrical pattern. .....*P. citrinum* Thom.

2. Colonies showing dull yellow to olive buff shades in reverse, sometimes light brown shades; penicilli suggesting divaricate and somewhat irregular pattern. .....*P. steckii* Zaleski.

3. Colonies quickly becoming greenish olive or dark green shades in reverse on Czapek, Steep or Koji-extract agar; penicilli mostly suggesting symmetrical pattern. .....*P. citreo-virens* Abe.

b. Conidia elliptical to subglobose.

1. Usually unequal in length of metulae, 2 to 3 or occasionally 5 verticils; colony reverse in light brown or fuscous shades.

.....*P. corylophilum* Dierckx.

2. Usually unequal in length of metulae, 5 to 8 verticils; colony reverse in colorless or pale yellow shades.

.....*P. corylo-philoides* Abe.

3. Usually equal in length of metulae, 5 to 8 verticils, and closely compact; colony reverse in dull yellow shades.

.....*P. paxilli* Bainier.

(2. Penicilli typically rebranched below the level of metulae, with main axes and branches terminating in verticils of metulae; usually growing at 5°C.

A.)) Penicilli commonly long, with elements loosely arranged and often divergent.

1.)) Conidiophores smooth walled or nearly so.

1) Conidia less than 4.5 μ in long axis; conidial chains often adherent into well-defined columns.....*P. chrysogenum* series.

a. Conidia elliptical to ovate, occasionally subglobose.

a-1. Seldom growing on Sakaguchi & Wang agar; conidia usually more than 3.0 μ in long axis.

1. Colonies usually showing abundant yellow exudate and yellow pigmentation in reverse and surrounding agar.

.....*P. chrysogenum* Thom.

Tan mutant. .....P. chrysogenum Thom mut. fulvescens Takashima, Arima and Abe.

2. Colonies showing pale or colorless exudate and surrounding agar, brownish colors throughout in reverse. .....*P. meleagrinum* Biourge.

a-2. Luxuriantly growing on Sakaguchi & Wang agar, conidia usually less than 3.0 μ in long axis, conidial areas quickly dull green shades.

.....*P. meleagrinum* Biourge var. *viridi-flavum* Abe.

b. Conidia globose to subglobose; seldom growing on Sakaguchi & Wang agar.

1. Agar surrounding colonies usually broadly yellow pigmented; exudate bright yellow color.

.....*P. notatum* Westling.

2. Agar surrounding colonies usually colorless; exudate colorless or tardily pigmented.

.....*P. cyaneo-fulvum* Biourge.

2) Conidia commonly 4.5 μ or more in long axis, strongly elliptical.

a. Conidia elliptical, fairly uniform in size.

.....*P. oxalicum* series.

a-1. Luxuriantly growing at 37°C; colonies plane or nearly so, conidia often forming deep crusts.

.....*P. oxalicum* Currie and Thom.

a-2. Seldom growing at 37°C; colonies radially furrowed, not forming deep crusts, reverse in reddish to maroon shades. .....*P. atramentosum* Thom.

b. Conidia strongly cylindrical to elliptical, varying greatly in size and often very large; penicilli very irregular, often fragmentary. .....*P. digitatum* series.

b-1. Colonies rather restrictedly spreading, conidial areas dull yellow green shades. .....*P. digitatum* Saccardo.

b-2. Colonies rather broadly spreading, conidial areas blue-green shades.

.....*P. digitatum* Saccardo *var. latum* Abe.

b-3. Conidia white; otherwise duplicating the species.

.....*P. digitatum* Sacc. var. *californicum* Thom.

2.)) Conidiophores typically rough-walled.

.....*P. roqueforti* series.

a. Conidia globose rarely subglobose; colonies usually plane or slightly furrowed on Czapek agar.

a-1. Conidia smooth walled or nearly so; conidiophores walls with protuberances or larger granules (about 0.6 to 1.0 μ in length); luxuriantly growing on Sakaguchi & Wang agar;

margin thin and often arachnoid. .....*P. roqueforti* Thom.

a–2. Conidia delicately echinulate or verruculose walled; conidiophores walls punctate or with smaller granules; poorly growing on Sakaguchi & Wang agar; rather compact, seldom producing arachnoid margin.
.....*P. roqueforti* Thom var. *punctatum* Abe.

b. Conidia elliptical or ovate to subglobose; usually radially furrowed.

b–1. Seldom growing on Sakaguchi & Wang agar.

1. Conidia elliptical to subglobose, smooth walled or nearly so; reverse and surrounding agar usually strongly pigmented. .....*P. casei* Staub.

2. Conidia ovate to subglobose with spinulose walls; reverse in pinoceous pink shades, surrounding agar milky-like pigment; penicilli suggestive of the *P. brevi-compactum* series. .....*P. casei* Staub var. *compactum* Abe.

b–2. Luxuriantly growing on Sakaguchi & Wang agar; conidia elliptical to ovate with delicately echinulate or verruculose walls; reverse and surrounding agar colorless or pale yellow shades. .....*P. pseudo-casei* Abe.

B.)) Penicilli comparatively short, compact, with all elements closely pressed. .....*P. brevi-compactum* series.

1. Conidia globose to subglobose; branches and metulae commonly inflated. .....*P. brevi-compactum* Dierckx.

2. Conidia elliptical to subglobose, with echinulate or verruculose walls; colonies in yellow green shades.
.....*P. stoloniferum* Thom.

3. Conidia elliptical to subglobose, with echinulate or verruculose walls; colonies in brownish shades.
.....*P. brunneo-stoloniferum* Abe.

(2) Colonies typically lanose or floccose, with conidiophores commonly long, usually arising as branches from aerial hyphae or from the substratum in marginal areas in older colonies. .....Lanata Sub-section.

a. Colonies predominantly white and remaining so or becoming light gray-green with the development of ripe conidia.
.....*P. camemberti* series.

b. Colonies quickly developing some shades of green in conidial areas.
.....*P. commune* series.

(3) Colonies with surface typically ropy or funiculose from aggregation of aerial hyphae; conidial structures arising primarily from aerial hyphae or ropes of hyphae. .....Funiculosa Sub-section.

a. Conidial areas in yellow-green, blue-green, or gray-green shades; penicilli large, as in the Lanata and Fasciculata; conidia subglobose to elliptical. .....*P. terrestre* series.

b. Conidial areas variously colored but never in green shades; penicilli often comparatively narrow; conidia strongly elliptical to cylindrical. .....*P. pallidum* series.

(4) Colonies with surface growth appearing mealy, tufted, fasciculate, or coremiform due to aggregation of conidiophores into upright fascicles or bundles. .....Fasciculata Sub-section.

a. Sclerotia characteristically produced. .....*P. gladioli* series.

b. Sclerotia not produced.

((A. Colonies with simple conidiophores and fascicles intermixed, but with simple conidiophores usually predominating.

((1. Colonies lacking true green colors in areas of ripe conidia. .....*P. ochraceum* series.

1. Conidial areas in yellowish olive, buffy olive or buffy brown shades. .....*P. ochraceum* (Bainier) Thom.

2. Conidial areas in lighter shades near sandy brown or pinkish buff. .....*P. carneo-lutescens* Smith.

3. Conidial areas colorless or in light cream shades. ..... Color mutants of *P. claviforme* and *P. urticae* and other species.

((2. Colonies characteristically developing yellow-green, blue-green or gray-green shades in areas of ripe conidia; seldom growing at 37°C.

1) Conidiophores usually conspicuously rough-walled, seldom growing on Sakaguchi & Wang agar.

A) Conidia forming definite crusts which easily break away when the culture tube or dish is tapped.

.....*P. crustosum* series.

.....*P. crustosum* Thom.

B) Conidia forming compact crusts which seldom break away when the culture tube or dish is tapped.

.....*P. viridi-cyclopium* series.

1–. Conidia globose or subglobose, smooth or nearly so.

a. Agar surrounding colonies usually quickly and broadly pigmented.

1. Colonies remaining bright yellow-green in age or tardily becoming light brown shades.

.....*P. viridicatum* Westling.

2. Colonies blue-green slightly bluish-yellow-green or dull yellow-green shades.

.....*P. viridi-cyclopium* Abe.

b. Agar surrounding colonies colorless or tardily weakly pigmented.

1. Colonies at first bright or dull yellow-green shades but quickly olive or gray green shades.

.....*P. olivino-viride* Biourge.

2. Conidial areas quickly developing dark yellow-green shades. .....*P. palitans* Westling.
3. Colonies in blue-green shades but quickly grayish olive shades, slightly fasciculate or often velutinous appearing. .....*P. puberulum* Bainier.

2–. Conidia globose to subglobose with echinulate or verruculose walls.
1. Colonies in yellow-green shades.
.....*P. palitans* Westling var. *echinoconidium* Abe.
2. Colonies in blue green shades. .....*P. cyclopium* Westling var. *echinulatum* Raper, Thom and Fennell.

3–. Conidia elliptical to ovate with smooth or nearly so walls.
1. Conidia elliptical or ovate, colonies in blue-green shades.
.....*P. cyclopium* Westling.
2. Conidia strongly elliptical; non-sporulating and tardily and sparsely growing on malt agar.
.....*P. aurantio-virens* Biourge.

2) Conidiophores smooth walled or nearly so, conidia elliptical.
.....*P. urticae & italicum* series.

a. Seldom growing on Sakaguchi & Wang agar.
1. Sterigmata seldom more than 6.5 μ in length.
.....*P. urticae* Bainier.
2. Sterigmata usually more than 6.5 μ in length.
.....*P. expansum* (Link) Thom.

b. Usually growing on Sakaguchi & Wang agar.
1. Conidia seldom cylindrical form, colonies in blue-green shades. .....*P. martensii* Biourge.
2. Conidia cylindrical form, colonies in blue or yellow green shades. .....*P. italicum* Wehmer.

((B. Colonies with most of the conidiophores arranged in fascicles or in definite coremia; seldom growing at 37°C.

A. Conidiophores typically rough walled.
.....*P. granulatum* series.
1. Conidia globose to subglobose.
.....*P. corymbiferum* Westling.
2. Conidia elliptical. .....*P. granulatum* Bainier.

B. Conidiophores smooth walled or nearly so.
.....*P. clavi-forme* series.
1. Colonies poorly growing on Sakaguchi & Wang agar; coremia typically club-shaped and showing clear differentiation into a compact fibrous stalk and an expanded " sporehead " composed of massed and interwoven penicilli.
1-1. Conidial areas in green shades.
.....*P. claviforme* Bainier.

1–2. Conidial areas usually white.
.....*P. claviforme* Bainier mut. ***candicans*** Abe and Ura.
1–3. Conidal areas in olive colors.
.....*P. claviforme* Bainier mut. ***olivicolor*** Abe and Ura.
2. Luxuriantly growing on Sakaguchi & Wang agar; coremia typically loose in texture (Isaria-like), often not clearly differentiated into stalk and "sporehead"; commonly appearing feathery, with penicilli usually separate.
.....*P. clavigerum* Demelius.

III. Penicilli characteristically biverticillate and symmetrical, but sometimes fractional in some species and strains; sterigmata typically lanceolate, with apices long-tapered, acuminate.
.....Biverticillata-Symmetrica Section.

(1–. Colonies typically producing perithecia or sclerotia.
A. Colonies producing soft perithecia upon most substrata, usually in bright yellow (luteus) shades. ..... *P. luteum* series. (Same as: Raper, Thom and Fennell, op. cit., pp. 561–562. 1949.)
B. Colonies producing perithecia or sclerotia in greater or lesser abundance upon most substrata. (Same as: Raper, Thom and Fennell, op. cit., p. 562. 1949)

(2–. Colonies not producing perithecia or sclerotia.
A. Colonies regularly developing abundant, erect coremia, ofthen characterizing the culture.
1. Colonies luxuriantly growing at 37°C; penicilli typically biverticillate and symmetrical; sterigmata lanceolate, with tips gradually tapered; colonies develonping yellow orange, olive brown or red shades in reverse. .....*P. duclauxi* series.
.....*P. duclauxi* Delacroix.
2. Colonies seldom growing at 37°C; penicilli typically asymmetrical; sterigmata with tips more abruptly narrowed; colonies seldom developing true red shades in reverse. .....*P. claviforme* series.
B. Colonies seldom or never developing true coremia.
((1)) Colonies usually growing at 37°C.
–(A. Colonies with surface appearing funiculose, floccose-funiculose, or somewhat tufted; conidiophores arising primarily from hyphae or ropes of hyphae. .....*P. funiculosum* series.
(a. Conidial chains tangled or divergent; metuale parallel or somewhat divergent.
(1. Conidia strongly elliptical or fusiform, smooth or nearly so; colonies usually developing reddish shades in reverse.
a)– Colonies seldom growing on Sakaguchi & Wang agar.
1. Colonies usually spreading broadly; metulae closely parallel or somewhat divergent.
.....*P. funiculosum* Thom.

2. Colonies usually more or less restricted; colonies bristly, showing areas of red, orange or yellow mycelium and dark green conidia; conidia usually fusiform.
.....*P. islandicum* Sopp.

b)- Colonies luxuriantly growing on Sakaguchi & Wang agar; colonies usually spreading broadly; metulae more or less divergent, seldom closely parallel. .....*P. purpurogenum* var. *rubri-sclerotium* Thom (non-sclerotigenic type.)

(2. Conidia never strongly elliptical or fusiform; colonies never developing true red shades in reverse.

1. Conidia globose or ovate, typically verruculose walls.
.....*P. verruculosum* peyronel.

2. Conidia ovate or sometimes elliptical, with smooth or slightly rough walls; but fractional penicilli usually abundant; conidiophore production suggesting the foot cell of *Aspergillus*. .....*P. varians* Smith.

(b. Conidial chains forming a conical or pyramidal mass; metulae numerous, incurved. .....*P. piceum* Raper and Fennell.

-(B. Colonies typically velvety or lanose; conidiophores arising primarily from the substratum or from the basal felt.
.....*P. purpurogenum* sesies.

-(1. Colonies consistently producing deep red colors in reverse; surface usually heavy sporing and showing an evident but limited development of yellow or orange-red aerial hyphae.

a) Strong pigmentation diffusing throughout the surrounding agar; conidia elliptical to subglobose.

1. Metulae closely parallel; colonies growing rather rapidly, sometimes becoming broadly spreading; conidia smooth or slightly rougened. .....*P. purpurogenum* Stoll.

2. Metulae seldom parallel, usually more or less divergent; colonies more restricted; conidia smooth or nearly so.
.....*P. rubrum* Stoll.

b) Pigmentation seldom diffusing throughout the surrounding agar, but tardily developing very light shades; colonies usually developing rather rapidly and broadly.

1) Conidia with echinulate or verruculose walls.

1. Conidia globose or subglobose.
.....*P. aculeatum* Raper and Fennell.

2. Conidia usually ovate, occasionally with one end apiculate.
.....*P. aculeatum* Raper and Fennell var. *apiculatum* Abe.

2) Conidia smooth or nearly so, typical elliptical; metulae usually somewhat divergent; reverse usually in reddish shades in central or subcentral areas localized.

1. Sclerotia produced, at least when newly isolated; velutinous or slightly funiculose.
.....*P. purpurogenum* var. *rubri-sclerotium* Thom.
2. Sclerotia not produced when newly isolated; velutinous on Czapek agar, but typically funiculose on steep agar.
.....*P. purpurogenum* var. *rubri-sclerotium* Thom (non-sclerotigenic type.)

–(2. Colonies developing red-orange, yellow-orange or greenish brown rather than deep red colors in reverse; surface usually characterized by prominent areas of sterile yellow aerial mycelium.
.....*P. variable* Sopp.

((2)) Colonies seldom growing at 37°C, luxuriantly growing on Sakaguchi & Wang agar.

–(A. Conidiophores smooth or nearly so; colonies rather restricted; reverse varying from colorless or yellow to orange-brown shades, and sometimes greenish shades in localized areas; agar surrounding colony usually colerless or with limitedly diffusing heavy or light pigment; colonies velvety or velutinous.
.....*P. rugulosum* series.

1) Colonies usually rather restricted upon most media; conidia usually more than 3.0 μ in long axis.
a. Colony reverse usually orange-brown shades throughout or in localized areas, sometimes greenish shades in localized areas.
1. Conidia elliptical, echinulate or verruculose.
.....*P. rugulosum* Thom.
2. Conidia strongly elliptical, smooth or delicately roughened.
.....*P. concavo-rugulosum* Abe.
b. Colony reverse usually colorless or yellow shades throughout; colonies very thin throughout or with central area somewhat floccose, often wave-like zonate. .....*P. tardum* Thom.

2) Colonies growing very restrictedly; conidia usually less than 3.0 μ in long axis.
1. Metulae seldom numerous and somewhat divergent.
.....*P. diversum* Raper and Fennell.
2. Metulae numerous and definitely inflated or suggesting divaricate. .....*P. diversum* var. *aureum* Raper and Fennell.

–(B. Conidiophores with roughened walls; colonies developing strong green or greenish-brown shades in reverse; velvety or sometimes floccose.

(1. Conidiophores usually less than 6 μ or 7 μ in diameter.
–a. Conidia elliptical.
1. Conidia smooth or nearly so, strongly elliptical, near rugby-ball form; metulae numerous and suggesting divaricate;

conidiophore conspicuous roughened.
..... *P. herquei* Bainier and Sartory.

2. Conidia delicately echinulate, less than 3.4 μ in long axis; colonies usually spreading broadly; metulae not suggesting divaricate. .....*P. paraherquei* Abe.

3. Conidia with verruculose or granular walls; colonies growing rather rapidly. .....*P. estinogenum* Komatsu and Abe.

-b. Conidia globose or subglobose; sclerotia sometimes very abundant. .....*P. novae-zeelandiae* van Beyma.

(2. Conidiophores about 8 μ in diameter.
.....*P. olsoni* Bainier and Sartory.

IV. Penicilli large, usually symmetrical, typically branched at three or more levels below the sterigmata. .....Polyverticillata Section.
.....*P. albicans* series.
.....*P. albicans* Bainier.

MONOVERTICILLATA SECTION

Sclerotigenic species and varieties in the Monoverticillata

P. sclerotiorum van Beyma

FAT 1181. (1335).

The colony characteristics and micrscopic characters are shown in Tables C-1 and M-1, respectively.

The strain is assigned to *P. sclerotiorum* van Beyma (1937*; Raper, Thom and Fennel, 1949**) because of the production of abundant bright red mycelia accompanied by its sclerotia, the strictly monoverticillate form of its penicilli, the elliptical and smooth walls or nearly so of its conidia, and the production of smooth walls or nearly smooth conidiophores on Czapek agar.

However, this strain differs somewhat from other description: its conidia-producing areas are near Glaucous to American Green; the agar surrounding the colonies pigmented in a band about 4.0 to 5.0 mm. wide, in yellowish shades near Deep Chrome, becoming broadly diffused in the same shades; and its microscopic characteristics somewhat larger or smaller than described.

Strain FAT 1335, received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, as *P. sclerotiorum* van Beyma, their No. 6283, sent from Dr. S. Shibata, University of Tokyo, through Dr. H. Raistrick, London School of Hygiene, almost exactly duplicated FAT 1181 in cultural and microscopic characteristics.

* Beyma, Zentbl. F. Bakt. (II) 96: 416–419, fig. 1 and 2. 1937.

** Raper, K. B., Thom, C., and Fennell, D. I., A Manual of the Penicillia, 160–163. 1949.

P. thomii Maire

FAT 388.

The colony characteristics and microscopic characters are shown in Tables C–1 and M–1, respectively.

The strain is assigned to *P. thomii* Maire (1917*; Thom, 1910, 1930**; Raper Thom and Fennell, 1949***) because of the production of hard, rounded to oblony, yellow or orange sclerotia, the strictly monoverticillate form of its penicilli, the elliptical and smooth or nearly smooth walled conidia, and the production of orange red hyphae, not observed on Czapek or steep agar.

However, this strain differs somewhat from other descriptions: its conidial areas are near Artemesia Green; its sclerotia are near Maize Yellow or Orange Yellow, and 380 to 440 μ by 210 to 350 μ. Strain FAT 388 was received in 1954 from Mr. T. Kurada, National Institute of Hygiene, (their No. P 58), isolated from diseased rice.

* Maire, R., Bul. Soc. Hist. Nat. Afrique du Nord. 8: 189–192- 1917.

** Thom, C., The Penicillia, P. 173. 1930.; U. S. Dept. Agr., Bur. Anim. Ind., Bul. 118, P. 78. 1910.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia. 156–160. 1949.

P. thomii Maire var. *flavescens* Abe

FAT 340.

The colony characteristics and microscopic characters are shown in Tables C–1 and M–1, respectively.

Colonies on Czapek agar grow broadly, attaining a diameter of about 80 mm. in 10 to 12 days at 25°C; smooth or plane; in bright yellow green shades near Empire Green or Danube Green. with a margin 1.0 to 2.0 mm, wide; sclerotia produced abundantly, hard, oblong to rounded, 190 to 510 μ by 150 to 410 μ, in shades near Pinkish Cinnamon or Salmon Orange, embeded in evelopes of colorless sterile encrusted hyphae, and crushing with difficulty; composed of very thick-walled polygonal cells, mostly 8 to 15 μ in diameter, localized in the central area for 10 to 12 days, then scattered throughout the colony area (Fig. C–1.); exudate abundant or limited, pale yellow shades; reverse and surrounding agar in pale yellow shades; conidiophores arising from the substratum or basal felt, sometimes from aerial mycelium, mostly 90 to 300 μ long by 2.1 to 3.4 μ in diameter, with apices enlarged, up to 3.7 to 6.2 μ in diameter, with walls delicately granular; penicilli strictly monoverticillate; sterigmata in verticils of 8 to 14, parallel, mostly 9.3 to 10.6 μ by 1.7 to 2.5 μ, acute type with conidium-bearing tips somewhat narrowed; conidia elliptical or rarely subglobose, mostly 2.8 to 3.6 μ by 1.7 to 2.1 μ, with walls smooth or nearly so; chains of conidia in loose columns up to 60 to 160 μ in length; conidia with delicately roughened walls (protuberances less than 0.1 μ) in electron microscopy as shown in Fig. E–1.

Colonies on steep agar rather broad, about 63 mm. in 10 to 12 days at 25°C, loosely furrowed, turning to near Dusky Olive Green shades; reverse strongly yellow; other characteristics as described above for Czapek agar.

This strain differs markedly from *P. thomii* Maire (1927*; Raper, Thom and Fennell, 1949**) in the broad character of its growth, in the yellow green color of it colonies, and also in the production of usually elliptical form (about 500 μ in length), embedded in masses of white hyphae.

Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately fits the description of strain FAT 340. We, therefore, recognize this strain as representing a new variety to which the name *P. thomii* Maire var. *flavescens* Abe is assigned.

The varietal name is taken from the Latin, *flavescens* (meaning yellow), and is applied because of the yellow green color of its colonies.

* and ** See, *P. thomii* Maire.

P. cinnamopurpureum Abe

FAT 362, 363.

The colony characteristics and microscopic characters are shown in Tables C-1 and M-1, respectively.

Colonies on Czapek agar are rather restricted, attaining a diameter of about 16 to 20 mm. in 10 to 12 days at 25°C, buckled and slightly radially winkled; typically velvety, with a white narrow margin 0.5 mm. wide; more or less floccose from the development of abundant light vinaceous or brownish vegetal mycelium; conidial structures limited or abundant, marginal or localized, in bluish green shades near Bluish Glaucous; sclerotia in Pinkish Cinnamon becoming Wood Brown or Fawn, elliptical to subglobose; usually characterized by entire colonies composed of thick-walled sclerenchyma-like polygonal cells, hard, crushing with difficulty, mostly 10 to 18 μ in diameter; exudate abundant, in yellow or pinkish shades; odor limited, moldy; reverse in purplish shades in the marginal area, and near Dull Indian Purple becoming Dull Violet Black or Taupe Brown in the central area; pencilli strictly monoverticillate; conidiophores arising from the substratum or from aerial hyphae, seldom branched, smooth walled, 40 to 120 or 180 μ by 2.0 to 3.1 μ, with apices up to 3.1 to 5.0 μ in diameter; sterigmata in verticles of 5 to 8, parallel, mostly 10.6 to 12.6 or 15.6 μ by 2.0 to 3.0 μ, with conidium bearing tips somewhat narrowed; conidia elliptical to subglobose, 2.1 to 2.9 μ by 1.7 to 2.1 μ, with walls smooth or nearly so; chains of conidia in columns up to 60 to 200 μ in length; and conidia showing smooth or nearly so walls in electron microscopy (Fig. E-2.).

Colonies on steep agar are rather restricted, 25 to 26 mm. in 10 to 12 days at 25°C, and radially wrinkled; conidial area in pale yellow green shades near Sage Green, strongly purple shades in reverse; the other characters are as described above. This strain is suggestive of *P. sclerotiorum* van Beyma*, and *P. thomii* Maire**, *P. lapidosum* Raper and Fennell (1949***,

Raper, Thom and Fennell, 1949****) in the production of sclerotia with hard, sclerenchyma-like cells crushing with difficulty.

However, it differs markedly from *P. sclerotiorum* van Beyma in its infrequent development of bright orange-red mycelium, from *P. thomii* Maire in the abundant production of bright grayish, vinaceous or brownish mycelium, in the smooth or nearly so walls of its conidiophores, and also the dark puplish color in reverse, and from *P. lapidosum* Raper and Fennell in the restricted character of its growth, in the elliptical from of its sclerotia, and also in the purplish color of its reverse. In rddition, the strains differ markely from *P. pusillum* Smith (1939*****, Raper, Thom and Fennell,****** 1949) in the luxuriant production of sclerotia on Czapek agar, and in the elliptical form of their conidia.

Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characterizes the above strain. We therefore recognize the strains as representing a new species to which the binomial *P. cinnamopurpureum* Abe is assigned.

The specific name is taken from the Latin, *P. cinnamopurpureum* (meaning cinnamon-purple), and is applied because of the near cinnamon color of its sclerotia and the strong purplish color of its reverse.

* See, *P. sclerotiorum* van Beyma.

** See, *P. thomii* Maire.

*** Raper, K. B. and Fennell, D. I., Mycologia 40: 524–527, fig. 6. 1948.

**** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 163–166. 1949.

***** Smith, G., Brit. Mycol. Soc. Trans. 22: 254–255, PI. XVI, fig. 7 and 8. 1939.

****** Raper, K. B, Thom, C. and Fennell, D. I., A Manual of the Penicillia, 167–168. 1949.

Non-ascosporic species and varieties in the Monoverticillata

P. purpurrescens (Sopp) Raper, Thom and Fennell

FAT 13, 559, 732, 576.

The colony characteristics and microscopic charactersc are shown in Tables C–2 and M–2, respectively.

The strains are assigned to *P. purpurrescens* (Sopp) Rapper, Thom and Fennell (Sopp, 1912*; Thom,** 1930; Raper, Thom and Fennell,*** 1949) because of the broadly spreading growth, the reverse in reddish or brownish shades, the strictly monoverticillate penicilli, the globose or subglobose conidia with walls echinulate or granular (conspicuously echinulate or verruculose walls are shown by electron microscopy, Fig. E–3), and typically velvety texture.

However, the strains differ somewhat from other description: their conidial areas are dark bluish gray green and dark olive green shades; their sterigmata, compact or loose, in verticls of 3 to 7, or occasionally 13, are occasionally up to 10.0 to 15.6 μ in length; their conidia walls are conspi-

cuously echinulate or verruculose, and conidia measure 2.5 to 4.5 or 4.6 μ (excluding spines, 2.3 to 4.0 μ). Strain FAT 13 was received in 1949 from Dr. K. Sakaguchi****, University of Tokyo, as *Citromyces* No. 13. Another culture, FAT 782, received in 1954 from Mr. H. Iizuka, University of Tokyo, isolated from diseased rice, almost exactly duplicates the description of *P. purpurrescens* as presented above.

* Sopp, O. Monogr. pp. 117–119, Taf. XIV, fig. 102; Taf. XXII, fig. 4. 1912.

** Thom, C., The Penicillia, p. 179. 1930.

*** Raper, K. B., Thom, C., and Fennell, D. I., A Manual of the Penicillia, pp. 177–180. 1949.

**** Sakaguchi, K., Japanes Assoc. of Adv. Sci. No. 6. 726–730. 1930.

P. spinulosum Thom

FAT 571, 621, 14, 15, 1120, 668, 587, 639, 1137.

The colony characteristics and microscopic characters are shown in Tables C–2 and M–2, respectively.

The strains are assigned to *P. spinulosum* Thom (1910, 1930*; Raper, Thom and Fennell, 1949**) because of the broadly spreading character of growth, reverse colorless or pigmented in pale yellowish or pinkish shades, the strictly monoverticillate penicilli, the globose to subglobose conidia with spinulose walls, the acute shape and compact clusters of their sterigmata; and conidia with spinulose walls as seen in electron microscopy, as shown in Fig. E–4.

However, some strains differ markedly from the descriptions by Thom, and Raper, Thom and Fennell: in the pigmentation of their reverse on Czapek agar alants, FAT 571, 621, become Violet Slate or Dark Slate Violet in 15 to 30 days at 25°C and FAT 14, 15 become near Deep Slate Violet or Deep Varley's Gray in 16 to 30 days. The four strains differ from *P. trzebinskii* Zaleski in the form and character of the walls of their conidia. Strains FAT 1120, 668 and 1137 are suggstive of *P. frequentans* Westling in their typically velvety texture, but they differ in the character of conidial walls and in pigments developed in the colony reverse and surrounding agar.

Strains FAT 14, and 15 were received in 1949 from Dr. K. Sakaguchi,*** University of Tokyo, as *Citromyces* No. 14 and No. 15, isolated by him in 1930 from fresh and a dried persimmons.

Another culture, FAT 1340, was received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, as *P. spinulosum* Thom, (their No. 6054); it duplicates almost exactly the description of FAT 571 as presented above.

* Thom, C., U. S. Dept. Agr., Bur. Anim. Ind., Bul. 118, p. 76, Fig. 32, 1910; The Penicillia, pp. 183–184, fig. 21. 1930.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 180–185. 1949.

*** Sakaguchi, K., Japanese Assoc. of Adv. Sci. No. 6. 726–730. 1930.

P. lilacino-echinulatum Abe.*

FAT 84.

The colony characteristics and microscopic characters are shown in Tables C–2 and M–2, respectively.

Colonies on Czapek agar rather restrictedly, about 30 mm. in 10 to 12 days at 25°C; the central area is raised, and sulcate, the surface appearing typically funiculone, in pale gray green shades near Mineral Gray or Pale Olive Gray, chainging to Tea Green; exudate abundant, colorless; reverse in near Light Vinaceous Lilac in 6 to 7 days, changing to yellow shades, and the surrounding agar in pale yellow shades; penicilli strictly monoverticillate; conidiophores short, up to 20 to 40 μ in length by 1.2 to 1.9 μ in diameter, with walls smooth or nearly so, and apices enlarged up to 3.0 to 6.2 μ in diameter; sterigmata in crowded clusters, numbering 6 to 15 in a verticil, mostly 5.0 to 7.0 μ or rarely 9.3 μ in length by 1.5 to 2.5 μ in diameter, acute type with smooth walls or nearly so; conidia globose to subglobose, with typically echinulate or verruculose walls, mostly 2.1 to 2.8 μ in diameter; chains of conidia in parallel or loose columns, commonly up to 30 to 60 μ in length; and conidia showing conspicuously echinulate or verruculose walls in electron microscopy. (Fig. E–5, fig. C–3)

Colonies on steep agar are restricted, growing to about 37 mm. in 10 to 12 days at 25°C; the other characters are as described above.

This strain is separated from *P. restrictum* Gilman and Abbott** (1927; Thom; 1930, Raper, Thom and Fennell, 1949) and related species by the typically funiculose character of its colonies, their color, and the character of rarely growing on Sakaguchi and Wang agar.

The strain also differs markedly from *P. terlikowskii* Zaleski*** (1927, Thom, 1930; Raper, Thom and Fennell, 1949) in the pigments developed in the colony reverse, and in the character of the walls and sizes of the conidia.

Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characterizes the above strains. The author, therefore, recognizes this strain as representing a new species to which the binomial *P. lilacino-echinulatum* Abe is assigned.

The specific name is taken from the Latin, *lilacino-echinulatum* (meaning lilac-echinulate), and is applied because of the conspicuously echinulate character of conidia and production of colonies with reverse in lilac shade.

The correct placement of the species remains in doubt, but in appears to be most satisfactory assingnable to a series with *P. adametzi* Zaleski**** (1927; Thom, 1930; Raper, Thom and Fennell, 1949) in the Monoverticillata.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo) April. 1954.

** See, P. restrictum Gilman and Abbott.

*** See, P. terlikowskii Zaleski.

**** See, P. adametzioides Abe.

P. restrictum Gilman and Abbott.

FAT 779.

The colony characteristics and microscopic characters are shown in Tables C-2 and M-2, respectively.

The strain is assigned to *P. restrictum* Gilman and Abbott (1927*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the rather restricted character of its growth, the subfloccose character of its colonies, the dull gray color of its colonies, the yellowish reverse, the strictly monoverticillate form of the penicilli, the conidiophores short, with walls smooth or nearly so and the globose conidia with echinulate or granular walls.

Colonies on Sakaguchi and Wang agar grow rather restrictedly.

* Gilman, J. C., and Abbott, E. V., Iowa State College Jour. Sci. 1: 297, fig. 32. 1927.

** Thom, C., The Penicillia, pp. 176–177. fig. 20. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 223–225. 1949.

P. fuscum (Sopp) Raper, Thom and Fennell.

FAT 1343.

The colony characteristics and microscopic characters are shown in Tables C-2 and M-2, respectively. Electron micrograph is shown in Fig. E-6.

The strain is assigned to *P. fuscum* (Sopp) Raper, Thom and Fennell (Sopp, 1912*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the slow and restricted character of its growth, the subfloccose or funiculose character of its colonies, the olivaceous black color of its colonies, colorless in reverse and agar, the strictly monoverticillate form of its penicilli, the granular or punctate walls of the comparatively short conidiophores, and the globose conidia with tuberculate or granular walls.

However, this strain differs from other descriptions (by Sopp, Thom and Raper, Thom and Fennell) in the olivaceous black color of its conidia producing areas, and the sterigmata from 6.2 to 7.5 μ in length.

The strain, FAT 1343, was received in 1953, was received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, as *Citromyces fuscus* Sopp (their No. 6280).

* Sopp, O., Monograph pp. 120–122. Taf. XIV, fig. 100; Taf. XXII, fig. 6. 1912.

** Thom, C., The Penicillia, p. 180. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 226–227. 1949.

P. frequentans Westling.

FAT 103, 632, 627, 1029, 323, 1254, 1256, 826, 1032, 839, 570, 590, 1223, 12, 30.

The colony characteristics and microscopic characters are shown in Tables C-3 and M-3, respectively.

The strains are assigned to *P. frequentans* Westling (1911,* Biourge, 1023;** Thom, 1930;*** Raper, Thom and Fennell, 1949****) because of the monoverticillate form of their penicilli, the globose to subglobose, smooth or nearly smooth walled of their conidia, their erect conidiophores usually arising directly from the substratum, velvety or velutinous texture, with apices usually enlarged, the broadly spreading growth, and their reverse in yellow shades becoming orange-brown or brownish red.

However, the strains differ somewhat from former descriptions: some strains show dark bluish green shades in conidial areas, and others, dark yellowish green shades; the pigmentation of their reverse is strongly orange, brown or similar higher shades, sometimes zonated; the depth of their colonies, plane or deeper; and the characters of microscopic details, smaller or larger.

Strain FAT 1223 was isolated from soil in Japan; FAT 12 and 30 were received in 1949 from Dr. K. Sakaguchi*****, as *Citromyces* No. 12 and No. 30, isolated by him in 1930 from a papaya and Gulucon; these differ markedly from earlier descriptions in the production of colonies of typically funiculose texture on Czapek and Steep agar. Since they cannot be satisfactorily assigned to any other described form, however, they are assigned to this species because it is closest in cultural and microscopic chracters.

Strains FAT 1254 and 1256, received in 1951 from Prof. G. Yoneyama, University of Hiroshima, (their Nos. P 6 and P 2) were isolated from a "Toyama Ganyaku".

Strain FAT 103, was received in 1949 from Mr. T. Hasegawa, Institute for Fermentation, Osaka, (their No. P. 33)

Among other cultures, FAT 1391 and 1341, were received in 1955 from Dr. K. Kominami and Mr. K. Tuabaki, Nagao Institute, as *P. luteum* Zukal and *P. vinaceum* Gilman and Abbott, (their Nos. 6291 and 6055); FAT 1440 was received in 1955 from Dr. J. Fukumoto, Osaka Municipal Technological Research Institute, isolated from a fruit, (their No. M 12); FAT 1435 was received in 1955 from Dr. J. Fukumoto, as *P. glabrum* (Wehmer) Westling; FAT 1332 was received in 1955 from Division of Plant Breedings Blight, Tokai Kinki National Agricultural Experiment Station, Laboratory of Plant Desease, (their No. Pr-12); FAT 1317 was received in 1955 from Mr. I. Kanai, Department of Central Research Institute, Japan Monopoly Corporation for Tabacco Research, (their No. 8); all these strains duplicate almost exactly the description of *P. frequentans* as presented above.

* Westling, R., Arkiv for Botanik II: 58, 133–134, figs. 39, 78. 1911.

** Biourge, PH., La Cellule, 33: Fasc. I, pp. 292–293, Col. PI. X and PI. XVII, fig. 99. 1923.

*** Thom, C., The Penicillia, pp. 216–217. 1930.

**** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 172–177. 1949.

***** Sakaguchi, K., Japanese Assoc. Advancement of Science, No. 6. 726–730. 1930.

P. citreo-viride Biourge.

FAT 568, 1022, 1176, 1229, 967, 970, 959, 196, 567, 653, 960, 359, 360, 1023, 569, 326.

The colony characteristics and microscopic characters are shown in Tables C–3 and M–3, respectively.

The strains are assigned to *P. citreo-viride* Biourge* (1923; Thom,** 1930; Raper, Thom and Fennell, 1949***) because of the restricted character of their growth, the velvety, velutinous or subfloccose character of their colonies, the production of typical bright yellow color in reverse and in the agar surrounding the colonies, the strictly monoverticilate form of their penicilli, the short conidiophores with walls smooth or nearly so, the globose conidia with walls smooth or nearly so; and their conidia with delicately roughened walls (less than 0.1 μ measured by electron microscopy, as shown in Fig. E–7).

The strain may be clearly separated into four types on the basis of pigments developed in the colony reverse and the surrounding agar on Czapek and steep agar, the characteristic colonies, and also the characters of the colony surface. The first type is characterized particulary by the velvety or velutinous nature of its colonies, by the typical bluish green color, and also by the bright yellow color in reverse and agar; the second type is velutinous or subfloccose, dark bluish green shades, strongly bright yellow in reverse; the third is floccose or subfloccose, rather yellowish green, strongly bright yellow in reverse; and fourth floccose or subfloccose, bluish gray green, with light yellow shades in reverse.

However, this strain differs somewhat from other descriptions (by Biourge, Thom and Raper, Thom and Fennell) in the comparatively short (6.8 to 9.1 or 9.4 μ) sterigmata and the yellow-green color of its colonies (seen only in strains of the third type). Other cultures, FAT 1269, received in 1952 from Dr. H. Tsunoda, Food Research Institute, as *P. toxicarium* Miyake,**** FAT 1345, received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, as *P. toxicarium* Miyake, (their No. 6218) and FAT 745, received in 1953 from Mr. T. Hasegawa, Institute for Fermentation, Osaka, as *P. toxicarium* Miyake (their No. 4692) duplicate almost exactly the description of FAT 568 as given above. *P. toxicarium* Miyake is assigned to *P. citreo-virde* Biourge because of its globose conidia measuring 1.2 to 2.2 μ, with walls smooth or nearly so, and its delicately rough walled conidia, measuring less than 0.1 μ in electron microscopy. (Electron micrographs are shown in Fig. 8 and 9)

Other cultures, FAT 172, 179, 186, 223, 166, 196, 51 and 53, received in 1951 and 1955 from the Sakaguchi Laboratory, University of Tokyo, as *P. glaucum* (Brudny) Kral and the *P. luteum purpurogenum* series, *P. oxalicum*, *P. egypticatum* (Boarn), *P. divaricatum* Thom, *P. wortmani*, *Citromyces* Gn B, *Penicillium Gn* E, (their collection Nos. P–1–5, P–1–7, P–2–3, P–4–3, P–4–5, P–4–10, P–Naka–1–3) almost exactly duplicate the description of *P. citreo-viride* Biourge as given above.

* Biourge, PH., Monograph, La Cellule 33: fasc. 1, p. 299; Col. PL. IX and PI. XV, fig. 88. 1923.

** Thom, C., The Penicillia, pp. 199–200. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 215–218. 1949.

**** Miyake, I., Naito, H., and Tsunoda, H., Report of Rice Ultillization Lab. Japan. No. 1. 1940.

P. citreo-viride Biourge var. *aeneum* Abe.

FAT 124, 122, 123.

The colony characteristics and microscopic characters are shown in Tables C–3 and M–3, respectively. A colony's photograph and an electron micrograph are shown in Fig. C–4 and E–10, respectively.

Colonies on Czapek agar are rather restrictedly spreading, attaining a diameter of 22 to 30 mm. in 10 to 12 days at 25°C, typically velvety or velutinous, with a white narrow margin, 0.3 to 1.0 mm. wide, buckled or sulcate, some strains radiately furrowed, sporulating abundantly in pale yellow green shades near Sage Green or Vetiver Green, becoming Tea Green or Citrine Drab; exudate lacking or limited, pale yellow shades; odor lacking or slight, moldy; reverse in greenish yellow shades near Oil Yellow or Aniline Yellow in marginal area and in brownish shades in central area, localized; conidiophores usually arising from the substratum or basal felt, mostly 30 to 120 μ long by 1.7 to 2.3 μ diameter, with apices enlarged to 2.4 to 3.5 μ diameter, with apices enlarged to 2.4 to 3.5 μ in diameter and walls smooth or nearly so; penicilli strictly monoverticillate; sterigmata in verticils of 5 to 12, compact or loose, mostly 6.8 to 8.7 μ by 1.3 to 2.3 μ, acute type; conidia globose to subglobose, 1.5 to 2.3 μ, with smooth or nearly so walls; chains of conidia loosely parallel or in columns, up to 30 to 90 μ in length; its conidia showing delicately rough walls (spines lens than 0.1 μ) in electron microscopy.

Colonies on steep agar restrictedly spreading, up to 30 to 35 mm. in 10 to 13 days at 25°C; the other characters as described above.

Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characterizes the above strains, although they appear similar to *P. citreo-viride* Biourge (1923;** Thom, 1930;*** Raper, Thom and Fennell, 1949****).

They are separated from *P. citreo-viride* Biourge, however, by the pale yellow green color of their colonies, by the usually brownish color in the central area of the reverse, and by the typically velvety colony character.

The author therefore considers them a new variety to which the name *P. citreo-viride* Biourge var. *aeneum* Abe is assigned.

The verietal name is taken from the Latin, *aeneum* (meaning bronze), and is applied because of the brownish, near bronze, color of it reverse.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). April. 1954.

, *, **** See: *P. citreo-viride* Biourge.

P. vinaceum Gilman and Abbott.

FAT 1291.

The colony characteristics and microscopic characters are shown in Tables C-3 and M-3, respectively.

The strain is assigned to *P. vinaceum* Gilman and Abbott (1927*; Thom,** 1930; Raper, Thom and Fennell,*** 1949) because of the rather restrictedly spreading character of its growing, the typically funiculose character of its colonies, the deep vinaceous color of its reverse, the strictly monoverticillate form of its penicilli, the short conidiophores with smooth walls or nearly so, the ovate or subgloboe conidia with ends apiculate.

However, this strain differs somewhat from previous descriptions (by Gilman and Abbott,* 1927; Thom,** 1930; and Raper, Thom and Fennell,*** 1949) in the smooth or nearly so walls of its conidia.

FAT 1291, received in 1955 from Dr. K. Sakaguchi, University of Tokyo, was sent from Drs. K. B. Raper and D. I. Fennell, University of Wisconsin, (their NRRL 739), as *P. vinaceum* Gilman and Abbott.

* Gilman, J. C. and Abbott, E. V., Iowa State College Jour. Sci. 1: 299, fig. 34. 1927.

** Thom, C., The Penicillia, pp. 195–196, fig. 23. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 234–236. 1949.

P. multicolor Gregorieva-Manoilva and Poradielova.

FAT 637, 1208, 1051, 125, 934, 933, 1214, 1168, 929, 1216, 1230.

The colony characteristics and microscopic characters are shown in Tables C-3 and M-3, respectively.

The strains are assigned to *P. multicolor* G.-M. and P. (1915*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the rather restricted character of their growth, the production of yellow to range or orange-red vegetative mycelium, the production of yellow to orange and orange-red shades in the margin, the pigments in orange-red or red-brownish shades developed in their coloney reverse, the strictly monoverticillate penicilli, their conidiophores short and unbranched of the acute type, and their conidia with smooth or slightly spinulose walls, globose to subglobose of occasionally ovate.

However, this strain differs markedly from earlier descriptions (by G.-M. and P.; Thom; and Raper, Thom and Fennell.): the agar surrounding the colonies pigmented in yellow or orange shades; its conidia-producing areas in typically dark blue-green shades; and its conidia occasionally ovate, and 1.8 to 3.1 μ or up to 3.7 μ, with smooth or delicately roughened walls. Moreover, the conidial area of FAT 1051 usually appears at first in the center of the colony, and gradually extends towards the broad margin with abundant orange-red mycelia. According to the classification by Raper, Thom and Fennell, the strain should belong to a species in the floccose (or

lanose) type series. However, since it cannot be satisfactorily assigned to any other described form the author assigned it to this species because of the velvety appearance after 10 to 12 days, its conidiophres mostly arising from the basal felt and seldom branched, and the other character as described above.

Strains FAT 934, 933, 1214, 1186, 929, 1216, and 1230 differ somewhat from the others in the production of ovate to subglobose (nearly globose) conidia, and in texture, valutinous in 4 to 6 days, becoming deeply subfloccose or granular (appearance fascicle-like) in 10 to 15 days or more.

* Grigorieva-Manoilova, O. C. and Poradielova, N. N., Archives des Sciences Biologiques, Leningrad 19: 117–131, fig. 1 and one plate with photograph 1–6. 1915.

** Thom, C., The Penicillia, pp. 212–213. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 198–201. 1949.

P. roseo-purpureum Dierckx

FAT 780, 1288.

The colony characteristics and microscopic characters are shown in Tables C–3 and M–3, respectively.

The strains are assigned to *P. roseo-purpureum* Dierckx (1901*; Biourge,** 1923, 1925; Thom,*** 1930; Raper, Thom and Fennell,**** 1949) because of the restricted character of their growth, the subfloccose character of their colonies, the light grayish green color, the production of reddish color in reverse, the strictly monoverticillate form of their penicilli, the short conidiophores with smooth or nearly so walls, and the globose to subglobose conidia.

However, the strains differ somewhat from other descriptions (by Dierckx; Biourge, Thom, and Raper, Thom and Fennell): their conidia are globose to subglobose, mostly 2.0 to 3.0 μ, with walls smooth or nearly so; and their sterigmata are 10.6 to 12.5 μ in length.

Strain FAT 1288, received in 1952 from Dr. K. Sakaguchi, University of Tokyo, was originally sent from Drs. K. B. Raper and D. I. Fennell, University of Wisconsin (their NRRL 2065), as *P. roseo-purpureum* Dierckx.

* Dierckx, R. P., Soc. Sbientifique Bruxelles 25: p. 86. 1901.

** Biourge, PH., Monograph; La Cellule 33: fasc. I, pp. 317–319; Col. PI. XVI., fig. 96. 1923.; ibid. 36: 482. 1925.

*** Thom, C., The Penicillia, p. 181. 1930.

**** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 218–220. 1949.

P. terlikowskii Zaleski.

FAT 776, 1290.

The colony characteristics and microscopic characters are shown in Tables C–3 and M–3, respectively.

The strains are assigned to *P. terlikowskii* Zaleski (1927*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the rather restricted character of their growth, the typically funiculose character of their colonies, the reddish color of their reverse, the strictly monoverticillate form of their penicilli, the short and unbranched conidiophores with smooth walls or nearly so, the globose or subglobose conidia.

The strains differ markedly from other descriptions (by Zaleski, 1927; Thom, 1930; Raper, Thom and Fennell, 1949): their conidia are smooth walled or nearly so; the sterigmata of FAT 776 are longer than described mostly 9.3 to 15.6 μ; colonies of FAT 776 are in light gray green shades, near Vetiver Green.

Strain FAT 776, is suggestive of *P. vinaceum* Gilman and Abbott**** (1927; Thom 1930; Raper, Thom and Fennell, 1949) in the form of its conidia, but it differs markedly in the production of pigmented mycelium only rarely, in not developing deep vinaceous or purple colors in its reverse, and also in soldem growing on Sakaguchi and Wang agar. FAT 1290, received in 1952 from Dr. K. Sakaguchi, University of Tokyo, was sent from Drs. K. B. Raper and D. I. Fennell, University of Wisconsin, (their NRRL 2067), as *P. terlikowskii* Zaleski.

* Zaleski, K., Bul. Acad. Polonaise Sci.: Math, et Nat. Ser. B, pp. 501–502; Taf. 59. 1927.

** Thom, C., The Penicillia, pp. 203–204. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 231–234. 1949.

**** See, P. vinaceous Gilman and Abbott.

P. trzebinskii Zaleski.

FAT 252, 631.

The colony characteristics and microscopic characters are shown in Tables C–4 and M–4, respectively.

The strains are assigned to *P. trzebinskii* Zaleski (1927;* Thom, 1930;** Raper, Thom and Fennell,*** 1949) because of the rather broadly spreading character of their growth, the typically velvety or velutinous texture, the reverse developing near fusous shades, the strictly monoverticillate penicilli, the rather long conidiophores having punctate or small granular walls, the ellipitcal to ovate conidia with echinulate walls, and an ordor, indefinitely moldy or lacking.

However, this strain differs markedly from the descriptions given by Zaleski, Thom, Raper, Thom and Fennell: its conidia-producing area is in deep blue-green shades; its growth is rather broadly spreading.

Strain FAT 252 was received in 1952 from Mr. H. Kawada, Goverment Forestry Experimental Station, Japan, (their No. P–30), as *P. spinulosum* Thom.

* Zaleski, K., Bul. Acad. Polonaise Sci.: Math. et Nat., Ser. B, 1927.

** Thom, C., The Penicillia, p. 189. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 194–196. 1949.

P. trzebinskii Zaleski var. *magnum* Sakaguchi and Abe.*

FAT 24.

The colony characteristics and microscopic characters are shown in Tables C–4 and M–4, respectively. A colnoy's photograph and an electron micrograph are shown in Fig. C–5 and E–11, respectively.

Colonies on Czapek agar attain a diameter of 60 mm. in 10 to 12 days at 25°C, consisting of a sparse basal felt with thin aerial growth, appearing subfloccose but velutinous; seldom wrinkled and furrowed, and smooth or plane; conidial area sparsely sporulating throughout, in Stone Green becoming Light Yellowish Olive in age; exudate lacking; odor lacking; reverse usually colorless, turing to Drab shades, and surrounding agar seldom pigmented; conidiophores limited, commonly arising from submerged hyphae, sometimes from the aerial mycelium or the basel felt, variable in length, up to 170 to 440 μ and 2.0 to 3.8 μ in diameter, mostly unbranched, with the larger apices up to 3.7 to 5.0 μ in diameter, with walls punctate or small granular; penicilli strictly monoverticillate; sterigmata in verticils of 5 to 8, about 14.0 to 18.0 μ by 2.1 to 3.7 μ, compact or loose, acute type with conidium-bearing tips difinitely narrowed; conidia long elliptical to ovate, mostly 3.3 to 4.7 μ by 2.6 to 3.6 μ, with echinulate or granular walls seen in electron microscopy; and chains of conidia in loose columns or loosely parallel, up to 60 to 180 μ long.

Colonies on steep agar grow more rapidly, up to 70 mm. in 10 to 12 days at 25°C, but the other characters are as described above.

This strain differs from *P. purpurrescens* and the *P. spinulosum* species in its elliptical conidia with conspicuously rough walls. It is suggestive of *P. trzebinskii* Zaleski in the rapidly spreading character of its growth, the typically elliptical conidia with conspicuously rough walls, and also the rather long conidiophores with punctate or small granular walls.

The strain also differs markedly from the descriptions given by Zaleski**, Thom***, Raper, Thom and Fennell****, for *P. trzebinskii*, in the usual production of long elliptical conidia (3.3 to 4.7 μ in long axis), in the yellowish shades of its conidia-producing area, in its long sterigmata, and in the usual production of sparse colonies. Strain FAT 24 was received in 1949 from Dr. K. Sakaguchi, University of Tokyo, as *Citromyces* No. 24, isolated in 1930 from an Uhaku. We might expect to find some natural variation in morphological characters following continuous inoculation on artificial media for about twenty years, but the strain has remained unchanged in taxonomic characters during seven years under careful observation. Since this form cannot be satisfactorily assigned to any other described species, the author considers it as representing a new variety to which the name *P. trzebinskii* Zaleski var. *magnum* Sakaguchi and Abe is assigned. The

varietal name is taken from the Latin, *magnum* (meaning large), and is applied because of the large size of the conidia.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo) June. 1952.
, *, *** See, P. trzebinskii Zaleski.

P. trzebinskianum Abe.*

FAT 1138, 728.

The colony characteristics and microscopic characters are shown in Tables C–4 and M–4, respectively. A colony's photograph and an electron micrograph are shown in Fig. C–6 and E–12 and 13, respectively.

Colonies on Czapek agar attain a diameter of 42 to 48 mm. in 10 to 12 days at 25°C, growing fairly rapidly, consisting of somewhat compact basal felt, appearing valutinous or subfloccose, with a white margin 1.0 to 1.2 mm. wide, smooth or loosely radially furrowed, sporulating abundantly in darkish blue-green shades near Dusky Dull Green and in some, Dull Blackish Green in central areas; exudate lacking; odor definitely vanilla-like; reverse in yellowish green or vinaceous shades becoming olivaceous black, with surrounding agar in yellowish shades; conidiophores generally arising in a close stand directly from the substratum or basal felt, sometimes from aerial mycelium, mostly 60 to 280 μ long by 2.5 to 4.0 μ in diameter, with apices, up to 3.7 to 6.9 or 7.5 μ in diameter, with walls punctate or small granular, sometimes septated; penicilli strictly monoverticillate; sterigmata in verticils of 5 to 12, compact mostly 8.7 to 12.5 μ by 2.1 to 3.2 μ, acute type, with conidium-bearing tips sometimes narrowed; conidia elliptical to ovate or sometimes subglobose, mostly 2.5 to 3.8 μ by 2.3 to 3.1 μ, with walls echinulate and echinulate or verruculose walls observed in electron microscopy; chains of conidia in parallel or loose columns up to 30 to 190 μ in length. Colonies on steep agar spreading, up 43 to 54 mm. in 10 to 12 days, strongly radially furrowed, reverse near Umber shades becoming blackish brown, others characters as described above.

However, these strains differ from *P. fellutanum* Biourge** in the rapidly spreading character of their growth, the conspicuously roughened walls of their conidia, and the punctate walls of their conidiophores; they differ from *P. spinulosum* Thom*** in the elliptical conidia with conspicuously roughened walls.

Moreover, these strains are separated from *P. trzebinskii* Zaleski**** by the abundant production of a vanilla-like odor, by the darkish blue green shades of the conidial area, and by the rapidly spreading character of growth.

Therefore, since they cannnot be satisfactorily assigned to any other described form, author recognizes these strain as representing a new species to which the binomial *P. trzebinskianum* Abe is assigned.

The specific name is taken from the Latin, *trzebinskianum* (meaning trzebinskii-like), and is applied because of the (conspicuously) echinulate

character of the conidia, and the pigments developed in the colony reverse Czapek agar.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo) June. 1952.
** See: *P. fellutanum* Biourge.
*** See: *P. spinulosum* Thom.
**** See: *P. trzebinskii* Zaleski.

P. fusco-flavum Abe.*

FAT 1081.

The colony characteristics and microscopic character are shown in Tables C–4 and M–4, respectively. A colony's photograph and electron micrograph of conidia are shown in Figs. C–7 and E–14, respectively.

Colonies on Czapek agar grow rather heavy but restrictedly, attaining a diameter of 8 to 10 mm. in 10 to 12 days at 25°C; texture velutinous in marginal to subcentral colony area but somewhat subfloccose in central area, colony smooth or plane and somewhat raised in the center; conidial area in blackish yellow green shades near Dusky Yellowish Green with a lighter shades in the narrow, thin margin; exudate lacking; reverse colorless; conidiophores with punctate walls arising from the substratum, usually 15.0 to 30 μ by 2.2 to 3.7 μ, apices enlarged, to 3.7 to 6.2 μ in diameter; penicilli strictly monoverticillate; sterigmata mostly somewhat divergent, in verticils of 3 to 8, 6.2 to 7.5 μ by 1.7 to 3.0 μ, smooth walled or nearly so; conidia elliptical to subglobose, mostly 3.7 to 6.0 μ by 3.0 to 4.0 μ, with conspicuously echinulate or verruculose walls; chains of conidia tangled, up to 30 to 60 μ in length; and conidia showing conspicuously echinulate or verruculose walls in electron microscopy

Colonies on steep agar are heavy and restrictedly spreading, up to 10 mm. in 10 to 12 days at 25°C; the other character are as described above.

The strain differs markedly from *P. fuscum* (Sopp) Raper, Thom and Fennell (Sopp, 1912**; Thom, 1930***; Rapper, Thom and Fennell, 1949****) in the very restricted character of its growth, in the blackish yellow green color of its colony and also in its long elliptical conidia.

Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characterizes the above strain. Therefore, the author recognize this strain as representing a new species to which the binomial *P. fusco-flavum* Abe is assigned.

The species name is taken from the Latin, *fusco-flavum* (meaning dark yellow), and is applied because of the typical blackish yellow green color of its colonies. The correct placement of the species remains in doubt, but it appears to be most satisfactorily assignable to a series with *P. restrictum* Gilman and Abbott (Raper, Thom and Fennell, 1949) in the Monoverticillata.

The strain grows luxuriantly on Sakaguchi and Wang agar.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). April. 1954.
, *, **** See, P. fuscum (Sopp) Raper, Thom and Fennell.

P. lividum Westling.

FAT 877, 626, 73.

The colony characteristics and microscopic characters are shown in Tables C–5 and M–5, respectively.

The strains are assigned to *P. lividum* Westling (1911, 1914*; Thom, 1930**; Raper, Thom and Fennell,*** 1949) because of the fairly rapidly spreading character of growth, the loosely velutinous texture, the colony reverse in pale pinkish shades, the strictly monoverticillate penicilli; the smooth walls, long of conidiophores, and the elliptical to ovate or occasionally fusiform-like conidia and with smooth walls or nearly so.

However, the strains differ markedly from the descriptions given by Westling, Thom, and Raper, Thom and Fennell: their conidia-producing areas are in yellow green shades; their conidia, elliptical to ovate and occasionally fusiform-like and smooth walled or nearlly so, without visible spiral banding; and the conidial area appears first in the center and gradually extends toward the margin. The culture is called floccone in Raper, Thom and Fennell's classification, but a velutinous texture in developed after 7 to 12, or more, days.

Another culture, FAT 1336, received, in 1955 from Dr. K. Kominami and Mr. Tubaki, Nagao Institute, as *P. thomii* (Thom) Maire, (their No. 6290), duplicates almost exactly the description of FAT 877 as presented above.

* Westling, R., Arkiv for Botanik II: 58, 134–137, 1911; Dale, Ann. Myeol. 12: 52. 1914.

** Thom, C., The Penicillia, pp. 205–206. 1930.

*** Raper, K. B., Thom, C and Fennell, D. I., A Manual of the Penicillia, pp. 190–192. 1949.

P. aurantio-violaceum Biourge.

FAT 1008, 121, 649, 74, 561, 601.

The colony characteristics and microscopic characters are shown in Tables C–5 and M–5, respectively.

The strains are assigned to *P. aurantio-violaceum* Biourge (1923;* Thom,** 1930; Raper, Thom and Fennell,*** 1949) because of the broadly spreading character of their growth, the velutinous or loose texture, the broad and thin colony margin, the reverse developing pale violet or purplish shades in 5 to 7 days, the strictly monoverticillate penicilli, the rather long conidiophores with smooth, punctate or small granular walls, and elliptical or ovate conidia with smooth or slightly spinuliose wals.

However, this strain differs markedly from the descriptions by Biourge; Thom; and Raper, Thom and Fennell: its conidia-producing area develops rather dark yellowish green shades in 5 to 7 days, changing to pale yellow, not changing to near Quaker Drab on Czapek agar; and its conidia are elliptical to ovate or subglobose, rarely fusiform.

* Biourge, PH., Monogr., La Cellule 33: fasc. 1 pp. 282–284; Col. PI. X and PI. XVI, fig. 94. 1923.

** Thom, C., The Penicillia, p. 208. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 192–194. 1949.

P. chermisinum Biourge.

FAT 1287.

The colony characteristics and microscopic characters are shown in Tables C–5 and M–5, respectively.

The strain is assigned to *P. chermisinum* Biourge (1923*; Thom, 1930**; Raper, Thom and Fennell,*** 1949) because of the fairley rapid character of its growth, the funiculose or subfloccose character of its colonies, the gray-green color of its colonies, the production of reddish color in reverse, the strictly monoverticillate form of its penicilli, the elliptical conidia with walls smooth or neary so.

However, this strain differs somewhat from the description given by Raper, Thom and Fennell: its conidial area is Water Green becoming Tea Green or Olive Buff; its reverse is Vinaceous Fawn becoming Pale Vinaceous Fawn or Pompeian Red; its sterigmata 8.1 to 10.6 μ in length; and its conidia elliptical, 2.3 to 3.0 μ by 1.4 to 2.0 μ. The strain is characterized particularly by its size; it attains a diameter of 42 mm. in 10 to 12 days at 37°C on Czapek agar, and its reaches 50 mm. on steep agar. Strain FAT 1287 was received in 1.52 from Dr. K. Sakaguchi, University of Tokyo, originally sent from Drs. K. B. Raper and D. I. Fennell, University of Wisconsin, (their NRRL 2048), as *P. chermesinum* Biourge.

* Biourge, PH., Monograph, La Cellule 33: fasc. I. pp. 284–285. PI. X and PI. XVI, fig. 95. 1923.

** Thom, C., The Penicillia, pp. 192–193. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 206–209. 1949.

P. phoeniceum van Beyma.

FAT 1292.

The colony characteristics and microscopic characters are shown in Tables C–5 and M–5, respectively.

The strain is assigned to *P. phoeniceum* van Beyma (1933*; Raper, Thom and Fennell,** 1949) because of the very restricted character of its growth, the typically funiculose character of its colonies, the strongly purplish color of its reverse and agar, the strictly monoverticillate form of its penicilli, the delicately punctate walls of its short conidiophores, and the elliptical or apiculate conidia with walls smooth or nearly so.

FAT 1292, received in 1955 from Dr. K. Sakaguchi, University of Tokyo, was sent from Drs. K. B. Raper and D. I. Fennell, University of Wisconsin, (their NRRL 2070), as *P. phoeniceum* van Beyma.

* van Beyma, F. H., Zentbl. f. Bakt., etc., (II) 88: 136–137, fig. 4 and 5. 1933.
** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 236–238. 1949.

P. implicatum Biourge.

FAT 825, 1218, 1220, 977, 137, 1299, 563, 640, 807, 813, 936, 829.

The colony characteristics and microscopic characters are shown in Tables C–5 and M–5, respectively.

The strains are assigned to *P. implicatum* Biourge (1923*; Thom,** 1930; Raper, Thom and Fennell,*** 1949) because of the rather restricted character of their growth, the velvety or velutinous texture, their conidial area in blue-green shades, their reverse in yellow or purplish or orange or red shades, their monoverticillate penicilli, their conidiophores with smooth or nearly so walls short and seldom branched, their acute type sterigmata in compact clusters, and their elliptical to subglobose conidia with walls smooth or nearly so.

The strain may be divided into the following four types on the basis of pigments developed in the colony reverse upon Czapek agar and also in the color of the conidia-producing areas and the character of the colony surface: the first type is characterized particularly by the distinctly bright yellow pigment of its reverse; the second is characterized particulary by the typically violet or purplish shades of its reverse, developed in 3 to 5 days, becoming bright yellow; the third has a typically radially furrowed colony and pigments developed in the colony reverse as in type 2; the fourth is distinguished by its conidia-producing area in near bluish gray green shades and by its reverse, at first in typically yellow shades, gradully beboming orange red to bright red in one month.

In addition, the first, second and fourth types are particularly characterized by the smooth surface, raised in the central area.

Strains, FAT 563 and 640 are suggestive of *P. chrysogenum* Thom var. Q 176 in the production of typically radiately furrowed colonies, but they differ markedly from other descriptions (Biourge; Thom; Raper, Thom and Fennell); they are assigned to *P. implicatum* Thom as they duplicate almost exactly the other characters of FAT 1299 as presented above.

Another culture, FAT 1324, received in 1955, from Mr. I. Kannai, Department of Central Research Institute, Japan Monopoly Corporation Tabacco Research, as their No. 9, almost exactly duplicates FAT 825 in cultural and microscopic characteristics.

* Biourge, PH., Monograph, La Cellule 33: fasc. I, pp. 278–280; col. Pl. IX and Pl. XIV, fig. 82. 1923.
** Thom, C., The Penicillia, pp. 210–211. 1930.
*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 201–203. 1949.

P. sublateritium Biourge.

FAT 328, 367.

The colony characteristics and microscopic characters are shown in Tables C–5 and M–5, respectively.

The strains are assigned to *P. sublateritium* Biourge (1923*; Thom,** 1930; Raper, Thom and Fennell,*** 1949) because of the restricted character of their growth, the typical blusih gray green color of its conidial area, the velvety character of colonies on Czapek and steep agar, the production of a brick red color in reverse, the strictly monoverticillate form of their penicilli, the conidiophores with smooth or nearly so walls and mostly arising erect from the substratum or basal felt, and unbranched, and the elliptical conidia with walls smooth or nearly so.

However, this strain differs somewhat from earlier descriptions (by Biourge, Thom, and Raper, Thom and Fennell) in details of its characterstics.

Another culture, FAT 1325, received in 1955 from Mr. I. Kannai, Department of Central research Institute, Japan Monopoly Corporation Tobacco Research, as their No. Shi 1, almost exactly duplicates the description FAT 328 as given above.

* Biourge, PH., Monograph, La Cellule 33: fasc. I, pp. 315–317; Col. PI. X and PI. XVI, fig. 92. 1923.

** Thom, C., The Penicillia, p. 222. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 203–205. 1949.

P. adametzioides Abe.*

FAT 1301, 1302.

The colony characteristics and microscopic characters are shown in Tables C–5 and M–5, respectively. A colony's photograph and an electron micrograph of conidia are shown in Figs. C–8 and E–15, respectively.

Colonies on Czapek agar are rather rapidly spreading, 33 to 39 mm. in 10 to 12 days at 25°C; typically velvety or funiculose, with a white margin 1.0 to 1.5 mm. wide and thin or slightly funiculose; smooth or sulcate, sometimes radially furrowed; colony depth 500 to 800 μ in the central area; sporulating throughout in pale yellow green near Greenish Glaucous Blue in the marginal area and Pea Green in the central area, becoming Sage Green or Pea Green; exudate limited or abundant, Sulphur or Aniline Yellow; reverse in orange or orange cinnamon shades, becoming reddish brown, Pale Vinaceous or Light Vinaceous Lilac, with surrounding agar strongly pigmented in Vinaceous Tawny, becoming Xanthin Orange or Pale Green Yellow; conidiophores generally arising from the substratum, sometimes from hyphae, short, commonly 30 to 120 μ by 1.8 to 3.1 μ, with apices enlarged 3.1 to 6.2 μ in diameter, with smooth walls or nearly so; penicilli strictly monoverticillate, comparatively short; sterigmata usually compact or

somewhat divergent, crowded verticils, numbering about 6 to 10, mostly 8.7 to 10.6 or rarely 15.6 μ by 1.8 to 2.5 μ, acute type with smooth walls or nearly so; conidia elliptical to subglobose, 2.3 to 3.3 μ by 1.5 to 2.5 μ, smooth walled or nearly so in optical and electron microscopy; and chains of conidia tangled, up to 30 to 90 μ in length.

Colonies on steep agar rather rapidly spreading, 37 to 39 mm. in to 10 to 12 days at 25°C, heavily sporulating throughout in near Tea Green shades; reverse strongly brown-red shades, with surrounding agar in reddish brown shades; the other characters as on Czapek.

However, this strains differ from former descriptions of *P. adametzi* Zaleski (by Zaleski,** 1927; Thom,*** 1930; Raper, Thom and Fennell,**** 1949) in the rather rapidly spreading growth, in the elliptical conidia with smooth walls or nearly so, in the sterigmata somewhat longer than *P. adametzi*, and in the velvety character of its colonies. Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characterizes the above strains. The author, therefore, regard the cultures in question as representing a new species, to which the binominal *Penicillium adametzioides* Abe is applied.

The specific name is taken from the Latin, *adametzioides* (meaning "adametzi-like"), and is appled because of the resemblance to *P. adametzi*.

The correct placement of the species remains in doubt, but it appears to be most satisfactorily assignable to a series with *P. adametzi* Zaleski in the Monoverticillata according to Raper, Thom and Fennell's classification.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo) April. 1954.

** Zaleski, K., Bul. Acad. Polonaise Sci: Math. et Nat. Ser. B, pp. 507–509; Taf. 47 and 61. 1927.

*** Thom, C., The Penicillia, pp. 194–195. 1930.

**** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 228–231. 1949.

P. decumbens Thom.

FAT 588, 708, 602, 603, 604, 1071.

The colony characteristics and microscopic characters are shown in Tables C–6 and M–6, respectively.

The strains are assigned to *P. decumbens* Thom (1910, 1930*; Raper, Thom and Fennell,** 1949) because of the restricted character of their growth, the velutinous, velvety or subfloccose character of their colonies, the reverse colorless or turning to a greenish cast or slightly pink color, the short, smooth walled or nearly so and unbranched conidiophores, the strictly monoverticillate form of their penicilli, the elliptical conidia with smooth or nearly so walls.

However, these strains differ more or less from the descriptions by Thom, and Raper, Thom and Fennell; FAT 588 has long sterigmata, up to 8.7 to 10.0 μ, occasionally to 11.2 μ, colonies in Pois Green or Vetiver Green becoming Grayish Olive; FAT 708 has floccose or slightly funiculose colo-

nies, near Light Paris Green, becoming Parrot Green, and fusiform-like or apiculate conidia; FAT 602, 603, 604 and 1071 produce a white overgrowth of mycelia on Czapek and steep agar (occasionally), the longer sterigmata occasionally up to 12.5 μ, conidiophores with apices occasionally enlarged to 3.1 to 4.0 or 6.2 to 8.7 μ.

Other cultures, FAT 63 and FAT 66, received in 1951 and 1955 from the Sakaguchi Laborotory, University of Tokyo, as their Nos. 7 (Dai) and 13 (Collection No. P-Naka-2-3 and P-Naka-2-6) almost exactly duplicate the description of FAT 588 as given above.

* Thom, C., U.S. Dept. Agr. Bur. Anim. Ind., Bul. 118, p. 71, fig. 28. 1910; The Penicillia, pp. 197-198. 1930.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 209-212. 1949.

P. decumbens Thom var. *atro-virens* Abe.*

FAT 329, 1140.

The colony characteristics and microscopic characters are shown in Tables C-6 and M-6, respectively. A colony's photograph and an electron micrograph are shown in Figs. C-9 and E-16, respectively.

Colonies on Czapek agar are rather restrictedly spreading, attaining a diameter of 25 to 28 mm. in 10 to 12 days at 25°C, typically velvety, with a white margin 0.2 mm. wide, typically radiately furrowed, sporulating abundantly in blackish yellow-green shades near Dusky Yellow Green or Dull Blackish Green, unchanging or becoming Dark Ivy Green; exudate limited, colorless; oder lacking or slight, moldy; reverse colorless throughout or in slightly greenish shades localized in the central area; conidiophores generally arising in a close stand directly from the substratum or basal felt, sometimes from aerial mycelium, mostly 50 to 120 μ or sometimes 250 μ long by 1.5 to 2.5 μ in diameter, with apices enlarged to 3.7 to 6.2 μ in diameter, with walls smooth or nearly so; penicilli strictly monoverticillate; sterigmata in verticils of 7 to 14, parallel or compact, mostly 6.8 to 9.3 μ or up to 13.7 μ by 1.7 to 2.5 μ, acute type with smooth walls or nearly so; conidia elliptical to subglobose, mostly 2.4 to 3.1 μ by 1.8 to 2.5 μ, with walls smooth or slightly rough, showing loosely or delitately roughened walls in electron microscopy; chains of conidia in columns or tangled, up to 60 to 130 μ in length.

Colonies on steep agar spreading, up to 30 to 32 mm. in 10 to 12 days at 25°C, the other characters as described above for Czapek apar.

However, at strains differ markedly from *P. decumbens* Thom (1910,** 1930; Raper, Thom and Fennell, 1949***) in the velevety character of their colony, and also its blackish yellow green color.

Careful consideration of all described species and varieties of Penicillia has failed to reveal one which adequately characterized the above strains. The author, therefore, regards the cultures in question as representing a

variety, to which the name *P. decumbens* Thom var. *atro-virens* Abe is applied.

The varietal name is taken from the Latin, *atro-virens* (meaning black-green), and is applied because of the blackish yellow-green color of the colonies.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). April. 1954.
, * See, *P. decumbens* Thom.

P. fellutanum Biourge.

FAT 767, 9.

The colony characteristics and microscopic characters are shown in Tables C–6 and M–6, respectively.

The strains are assigned to *P. fellutanum* Biourage (1923*; Thom**; Raper, Thom and Fennell,** 1949) because of the restricted character of their growth, the velvety or subfloccose character of their colonies, the production of weak vinaceous or yellow to pale brownish color in reverse, the strictly monoverticillate form of their penicilli, the smooth or nearly so walls of their short and unbranched conidiophores, and the elliptical to subglobose conidia with walls smooth or nearly so.

However, these strains differ somewhat from other descriptions (by Biourge, Thom, and Raper, Thom and Fennell) in the length of their sterigmata, up to 7.5 to 10.0 or 12.5 μ; and in FAT 9, in the yellow green color (near Dark American Green) of its colonies. Strains FAT 9, received in 1949 from Dr. K. Sakaguchi, University of Tokyo, as their *Citromyces* No. 9, isolated from an orange, was reported as subfloccose, bluish glaucous by Sakaguchi (1930)****.

* Biourge, Ph., Monograph, La Cellule 33; fasc. I, pp. 262–264. Pl. XIII and Pl. XXIII, fig. 133. 1923.
** Thom, C., The Penicillia, pp. 198–199, fig. 25. 1930.
*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 212–215. 1949.
**** Sakaguchi, K., Japanese Assoc. of Adv. Sci. No. 6, 726–730. 1930.

P. fellutanum Biourge var. *nigro-castaneum* Abe.*

FAT 623, 624.

The colony characteristics and microscopic characters are shown in Tables C–6 and M–6, respectively. A colony's photograph and an electron micrograph are shown in Figs. C–10 and M–17, respectively.

Colonies on Czapek agar are rather restrictedly spreading, attaining a diameter of 23 to 24 mm. in 10 to 12 days at 25°C, typically velvety or velutinous, with a white narrow margin, 0.2 mm. wide, bluckled and typically radiately furrowed, sporulating abundantly in dark blue-green shades near Dark Russian Green, becoming blackish green; exudate lacking; reverse colorless in marginal area and drab in the central area, localized, turning to pink in the marginal area and Clove Brown in the localized contral area;

conidiophores generally arising from a basal felt, or sometimes trailing or prostrate creeping hyhae, mostly 40 to 120 μ long by 1.7 to 2.0 μ diameter, with apices enlarged to 3.0 to 4.3 μ in diameter, and smooth walled or nearly so; penicilli strictrly monoverticiltate; sterigmata in varticils or 6 to 12, parallel, mostly 10.0 to 13.2 μ by 2.1 to 3.1 μ, acute type; conidia elliptical to subglobose, mostly 2.5 to 3.4 μ by 2.1 to 2.8 μ, with walls smooth or slightly rough and loosely or delicately roughened walls shown by elecron microscopy; chains of conidia in loose columns or parallel, up to 30 to 120 μ in length.

Colonies on steep agar are spreading, growing to 28 to 29 mm. in 10 to 12 days at 25°C, elevated in the central area; other features are as described above. Careful consideration of all described species of *Penicillium* has failed to reveal one which adequately characterizes the above strains, although they seem to be similar to *P. felltutanum* Biourge (1923**; Thom,*** 1930; and Raper, Thom and Fennell,*** 1949).

However, they differ markedly from *P. fellutanum* in the velutinous character of their colonies, the dark blue green color changing to blackish green, the growth at 37°C, the lehgth of their sterigmata, the production of a strongly brownish-red color in the colony reverse, and the production of a strongly red (near Grenadine Red) color of their broth by surface culture.

The author therefore regard the cultures in question as representing a new variety, to which the name *P. fellutanum* Biourge var. ***nigro-castaneum*** Abe is applied. The varietal name is taken from the Latin, ***nigro-castaneum*** (meaning clove-brown), and is applied because of the near Clove Brown color of its reverse.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). April. 1954.
, *, **** See, *P. fellutanum* Biourge.

P. capsulatum Raper and Fennell.

FAT 564, 565.

The colony characteristics and microscopic characters are shown in Tables C–7 and M–7, respectively.

The strains are assigned to *P. capsulatum* Raper and Fennell (1948*; Raper, Thom and Fennel,** 1949) because of the character of their growth, the velety or slighty floccose character of their colonies, the ramigenous monoverticillate form of their penicilli, the short and irregularly branching conidiophores with walls smooth or nearly so, and the strongly elliptical or capsule-shaped conidia with smooth or nearly so walls.

However, the strains differ from earlier descriptions (Raper and Fennell, 1948; Raper, Thom and Fennell, 1949) in the yellow or brownish, changing to red or brownish olive, color in reverse, and the near Pistachio-Green or Mytho Green color of their colornies.

* Raper, K. B. and Fennell, D. I., Mycologia 40: 528–530, fig. 7. 1948.
** Raper, K. B., Thom, C. and Fennell, D. I.., A Manual of the Penicillia, pp. 242–244. 1949.

P. cyaneum (B. and S.) Biourge.

FAT 741.

The colony characteristics and microscopic characters are shown in Tables C–7 and M–7, respectively.

The strain is assigned to *P. cyaneum* (B. and S.) Biourge (1923*; Thom, 1930**; Bainier and Sartory,*** 1913; and Raper, Thom and Fennell,**** 1949) because of the restricted character of its growth, the velutinous or subfloccose character of its colonies, the colorless reverse, somesimes becoming dull yellow, the ramigenous monoverticillate form of its penicilli, the short and irregularly branched conidiophores with walls smooth or nearly so, and the typically elliptical conidia with pointed ends and walls smooth or nearly so.

However, this strain differs somewhat from previous descriptions (by Biourge- 1923; Thom 1930; and Raper, Thom and Fennell, 1949) in the near Andover Green, becoming Hair Brown, color of its colonies, and the sterigmata longer (8.3 to 12.5 μ) than described.

* Biourge, Ph., Monograph, Liste Onomastique, La Cellule 33; fasc. 1, p. 102. 1923.

** Thom, C., The Penicillia, pp. 226–228. 1930.

*** Bainier, G. and Sartory, A., Bul. Soc. Mycol. France 29: 157–161. 1913.

**** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia. pp. 244–246. 1949.

P. charlesii Smith var. *rapidum* Abe.*

FAT 831, 734, 806.

The colony characteristics and microscopic characters are shown in Tables C–7 andtM–7, respectively. A colony's photograph and an electron micrograph are shown in Figs. C–11 and E–18, respectively.

Colonies on Czapek agar grow rather rapidly, attaining a diameter of 39 to 52 mm. in 10 to 12 days at 25°C; radiately furrowed, some strains buckled and raised in the central area; appearing velvety or nearly so; sporulating abundantly in dark yellow green shades near Dark American Green or Dark Yellowish Green, becoming Dark Dull Yellow Green or Dusky Olive Green with age, with a white margin, 0.3 to 1.0 mm. wide; exudate lacking; odor limited, moldy; reverse in dull greenish or purple vinaceous shades with surrounding agar colorless; conidiophores airising from creeping or closely interwoven aerial hyphae, simple or variously branched, variable in length, 30 to 120 μ by 2.0 to 3.1 μ in diameter, with apices 2.6 to 3.7 μ in diameter, and with walls smooth or nearly so; penicilli monoverticillate, ramigenous; sterigmata in verticils of 5 to 10, compact or somewhat divergent, mostly 7.9 to 11.2 or rarely to 12.5 μ by 1.5 to 3.1 μ, acute type with smooth walls or nearly so; conidia globose to subglose, mostly 1.9 to 3.4 or 3.7 μ, with smooth walls or nearly so; chains of conidia in compact or loose columns up to 30 to 90 μ in length; its conidia showing loosely rough walls in electron microscopy.

Colonies on steep agar grow rather rapidly, 44 to 48 mm. in 10 to 12 days at 25°C, the other characters are as described above.

These strains are suggestive of *P. charlesii* Smith (1933**; Raper, Thom and Fennell,*** 1949) in the prouction of monoverticillate and ramigenous penicilli, in the columnar form of their chains of conidia, and in the globose or subglobose character of their conidia.

However, they differ markedly from this species in the rather rapidly spreading character of their colonies, their dark yellowish green color, the purplish vinaceous color of their reverse (only in FAT 806), and the longer sterigmata up to 7.9 to 11.2 or 12.5 μ.

Careful consideration of all described species of *Penicillium* has failed to reveal one which adequately characterizes the above strains.

The author therefore regard the cultures in question as requesenting a new variety to which the name *P. charlesii* Smith var. *rapidum* Abe is applied.

The varietal name is taken from the Latin, *rapidum* (meaning rapid), and is applied because of the rather rapid character of growth.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). April, 1954.

** Smith, G., Brit. Myc. Soc. Trans. 18: 90–91, PI. V, figs. 7 and 8, 1933.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 248–250, 1949.

P. velutinum van Beyma.

FAT 1121, 891.

The colony characteristics and microscopic character are shown in Tables C–7 and M–7, respectively. An electron micrograph are shown in Fig. E–19.

The strains are assigned to *P. velutinum* van Beyma (1935*; Raper, Thom and Fennell, 1949**) because of the fairly rapid character of their growth, the dull olivish green color, the velutinous or subfloccose character of their colonies, the vinaceous or brownish color in their reverse, the sometimes strictly monoverticillate and usually ramigenous and irregulary branched penicilli, the short (or sometimes long) conidiophores with walls smooth or nearly so, and the globose to ovate conidia with typical conspicuously echinulate or verruculose wall.

However, these strains differ somewhat from former descriptions (van Beyma; Raper, Thom and Fennell) in the occasionally ovate form of their conidia and in the dull olive green shades of their colonies.

* van Beyma, F. H., Zentbl. F. Bakt. etc., (II) 91; 352–353, fig. 6. 1935.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 250–251, 1949.

BIVERTICILLATA-ASYMMETRICA SECTION

Divaricata Sub-secton

P. lilacinum Thom.

FAT 1233, 1190, 1085, 1308.

The colony characteristics and microscopic characters are shown in Tables C–8 and M–8, respectively.

The strains are assigned to *P. lilacinum* Thom (1910, 1930*; Raper, Thom and Fennell,** 1949) because of the more or less rapidly spreading character of growth, the floccose colonies, the vinaceous conidial area, the dark red-purple reverse, the light vinaceous surrounding agar, the typically biverticillate divaricate and asymmetrical, and occasionally monoverticillate, penicilli, the smooth or nearly so conidiophore walls, the metulae and branches variable in length and strongly divaricate or loosely compact, the sterigmata in loosely compact clusters and abruptly narrowly tapered, the conidia with walls smooth or nearly so and typical elliptical or fusiform shape, and the tangled conidal chains.

However, the strains differ somewhat from the descriptions (cited above) in the sterigmata mostly 6.2 to 9.4 μ in length, in the metulae mostly 6.2 to 11.2 μ in length, and in the conidia 2.5 to 3.7 μ in length, occasionally fusiform.

Strain FAT 1308 was received in 1954 from Dr. H. Naganishi, University of Hiroshima, as *P. lilacinum* species ?

Other cultures including FAT 1407, received in 1955 from Dr. Y. Kinoshita, Katura Laboratory, University of Niigata, as their No. P–sp (5), isolated from an Uzuriba; FAT 1480, received in 1955 from Dr. M. Kimata, Microbiological Laboratory, University of Kyoto, as *P. lilacinum* Thom, as (their No. P–1123) duplicated almost exactly the description as given above for *P. lilacinum*.

* Thom, C., U. S. Dept. Agr., Bur. Anim. Ind., Bul. 118, 72–75, fig. 30. 1910; The Penicillia, pp. 331–334. figs. 49 and 50. 1930.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 285–288. 1949.

Spicaria violacea Abbott.

FAT 1364.

The colony characteristics and microscopic characters are shown in Tables C–8 and M–8, respectively.

The strain is assinged to *Spicaria violacea* Abbott (1926*; Gilman and Abbott,** 1926; Thom, 1930***; Raper, Thom and Fennell, 1949****) because of the somewhat rapidly spreading character of growth, the subfloccose colonies, the Vinaceous Drab conidial areas, the typical bright yellow colors of the reverse, the yellow surrounding agar, the asymmetrical and

biverticillate divaricate penicilli, the smooth or nearly so conidiophore walls, the loosely compact or divergent metulae, the loosely compact and conspicuously tapered sterigmata, the fusiform or elliptical conidia with walls smooth or nearly so and the tangled conidial chains.

However, the strain differs somewhat from the descriptions (listed above) in its sterigmata mostly 9.3 to 15.6 μ in length, and the occasionally fusiform shape of its conidia.

Strain FAT 1364, received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, as *P. rubellum* (Bainier) Biourge, (their No. 6283) was isolated from siol in Japan.

* Abbott, E. V., Iowa State College Jour. Sci. 1: 26, fig. 3. 1926.
** Gilman, J. C. and Abbott, E. V., Iowa State College Jour. Sci. 1: 301. 1926.
*** Thom, C., The Penicillia, p. 335. 1930.
**** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 288–291. 1949.

P. janthinellum Biourge.

FAT 1156, 1167, 860, 1298, 1157, 1017, 894, 876, 217, 216, 1106, 214, 302, 1091, 687, 1192, 909, 1097, 680, 1101, 1102, 870, 861, 875, 901, 900.

The colony characteristics and microscopic characters are shown in Tables C–8 and M–8, respectively.

The strains are assigned to *P. janthinellum* Biourge (1923*; Thom, 1930**; Raper, Thom and Fennell, 1949****) because of the broady or rather rapidly spreading growth, the velutinous or subfloccose colonies, the red, pink or vinaceous mycelium produced in some strains and lacking in others, the yellow-green or blue-green conidial areas, the red-purple or red-brown shades localized or throughout the reverse, the colorless, vinaceous or pinkish surrounding agar, the typically biverticillate and asymmetrical, strongly divaricate and occasionally monoverticillate pencilli, the smooth or typically rough walled conidiophores, the branches rare, or one or more, smooth or rough-walled, the divergent arrangement and unequal metulae, the loosely compact or divergent and abruptly tapered sterigmata, the ovate or subglobose conidia, occasionally with one end apiculate, and with smooth or slightly rough walls, the tangled or loosely divergent conidial chains, and the condia showing delicately roughened walls in electron microscopy (Fig. E–20).

The strains are clearly separable into five types, as shown in Tables C–8 and M–8, based on the color of mycelium, the colors of conidial areas, pigmentation of reverse and surrounding agar, character of walls of the conidiophores, the pattern of penicilli, and also in the rate of growth.

However, they differ somewhat from the descriptions (cited above) in the sterigmata 12.5 to 13.7 μ in length, the rather rapidly spreading growth (38 to 40 mm. in 10 to 12 days) in some strains, and the usually ovate to subglobose conidia with one ends apiculate.

Other cultures, FAT 1383, received to 1955 from Dr. K. Kominami and

Mr. K. Tubaki, Nagano Institute, as *P. oligosporum* Saito and Minoura**** (1948), (their No. 6039) and FAT 1414, received in 1955 from Dr. K. Minoura, Laboratory of Wakamoto Co. Ltd., as *P. oligosporum* Saito and Minoura, duplicated almost exactly the description of *P. janthinellum* (FAT 1156 and 1167) as given above. (*P. oligosporum*; pertithecia not fromed, pencilli irregular monoverticillate and asymmetrial biverticillate divaricate, mixed; conidia ovate or subglobose with one end apiculate, with smooth walls or nearly so 2.3 to 3.8 μ by 1.8 to 2.8 μ).

Strains FAT 1467, received in 1955 from Mr. T. Hasegawa, Institute for Fermentation Osaka, as *P. janthinellum* Biourge, (their No. 4651) also duplicated almost exactly description of FAT 1106 as given above.

* Biourge, PH., Monograph, La Cellule 33: fasc. 1, pp. 258-260; Col. PI. VII and PI. XII, fig. 70. 1923.

** Thom, C., The Penicillia, pp. 238-241. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 299-303. 1949.

**** Saito, K. and Minoura, K., Jour. Ferm. Tech. Soc. Osaka, 26: 3-7. 1948.

P. simplicissimum (Oud) Thom.

FAT 883, 542, 112, 768, 211.

The colony characteristics and microscopic characters are shown in Tables C-8 and M-8, respectively.

The strains are assigned to *P. simplicissimum* (oud) Thom (1930*; Raper, Thom and Fennell,** 1949) because of the rather rapidly or broady spreading growth, the velutinous or subfloccose colonies, the blue gray green or dark green conidial areas, the dull yellow colors in the reverse, the usually colorless surrounding agar, the asymmetrical and biverticillate and strongly divaricate penicilli, the typical granular walls of the conidiophores, the divergent arrangement of branches and metulae, the loosely compact or divergent and abruptly narrowly tapered sterigmata, the elliptical or ovate conidia with walls echinulate or verruculose, and tangled form of the conidial chains.

The strains may be separated into two types as shown in Tables C-8 and M-8, on the characters of texture, form of conidia, pigmentation of the reverse, and colors of conidial areas.

Strain FAT 768, received in 1953 from Mr. T. Hasegawa, Institute for Fermentation, Osaka, was originally sent from Dr. K. B. Raper, (their NRRL 902) as *P. simplicimum* (Oud.) Thom.

However, the strains differ somewhat from the descriptions (cited above) in the dark yellow green shades conidial areas in some strains, and in the conidia mostly 2.3 to 3.7 μ long.

* Thom, C., The Penicillia, pp. 304-305. 1930.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 304-305. 1949.

P. ochro-chloron Biourge.

FAT 828, 991, 1011, 1111, 678, 682, 534, 906, 880, 873, 504, 1107, 381.

The colony characteristics and microscopic characters are shown in Tables C–8 and M–8, respectively.

The strains ars assigned to *P. ochro-chloron* Biourge (1923*; Thom,** 1930; Raper, Thom and Fennell,*** 1949) because of the rather rapidly spreading growth, the typically velevety or velutinous, in some strains subfloccos colonies, the yellow green or blue green conidial areas, the flesh color or orange reverse, the colorless surrounding agar, the typically asymmetrical and divaricate biverticillate, ofren irregular, penicilli, the typically granular walled conidiophores, the divergent metulae and branches with roughened walls, the loosely compact or divergent arrangement of abruptly narrowly tapered sterigmata, the elliptical conidia with echinulate or smooth or slightly rough walls, and tangled or loosely divergent conidial chains.

However, the strains differ somewhat from the descriptions (cited above) in the sterigmata, mostly 7.5 to 10.6 μ or 12.5 μ in length, and in the conidia measuring 2.5 to 4.1 μ in length in some strains.

Another culture, FAT 1468, received in 1955 from Mr. T. Hasegawa, Institute for Fermentation, Osaka, as *P. ochro-chloron* Biourge (their No. 4612) duplicated almost exactly the description of FAT 828 as given above.

* Biourge, PH., Monograph. La Cellule 33: fasc. 1, pp. 269–270; Col. Pl. X and Pl. XVII, fig. 100. 1923.

** Thom, C., The Penicillia, pp. 363–364. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 305–308. 1949.

P. piscarium Westling.

FAT 711, 881, 905.

The colony characteristics and microscopic characters are shown in Tables C–8 and M–8, respectively.

The strains are assigned to *P. piscarium* Westling (1911*; Biourge,** 1923; Thom,*** 1930; Raper, Thom and Fennell,**** 1949) because of the rather rapid somewhat restricted growth, the velvety, velutinous or subfloccose colonies, the blue green or dull green conidial areas, the colorless or pale yellow reverse, the usually colorless surrounding agar, the asymmetrical and divaricate biverticillate penicilli, occasionally of monoverticillate form, the typically smooth or nearly so conidiophore walls, the divergent arrangement of the metulae, the loosely divergent arrangement and abruptly narrowly tapered sterigmata, and the typically echinulate walls and elliptical form of the conidia.

The strains are clearly separable into two types, as shown in Tables C–8 and M–8, on the basis of character of colonies, and colors of conidial areas and reverse.

However, they differ somewhat from the descriptions (cited above) in

the rather rapidly or restrictedly spreading growth, and in the dull green shades of conidial areas in some strain.

Two other cultures, FAT 58, received in 1951 and 1955 from the Sakaguchi Laboratory, University of Tokyo, *Penicillium* PO 4, (their No. P-Naka-1-8) and FAT 1320 received from Mr. I. Kanai, Department of Central Research Institute, Japan Monopoly Corporation Tobaccos Research, as *P. jenseni* Zaleski, (their No. 14) duplicated almost exactly the description of *P. piscarium* Westling as given above.

* Westling, R., Arkiv for Botanik 11: 54, 86-88, figs. 13 and 55. 1911.

** Biourge, Ph., Monograph, La Cellule 33: 190-191, Col. Pl. XI, fig. 2 and Pl. XVIII, fig. 107. 1923.

*** Thom, C., The Penicillia, pp. 487-488. fig. 85. 1930.

**** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 308-309. 1949.

P. miczinskii Zaleski.

FAT 1116, 882, 908.

The colony characteristics and microscopic characters are shown in Tables C-8 and M-8, respectively.

The strains are assigned to *P. miczinskii* Zaleski (1927*; Thom, 1930**; Raper, Thom and Fennell, 1949****) because of the rather rapidly spreading growth, the velutinous colonies, the yellow green conidial areas, the yellow or yellow-orange reverse, the colorless and gradually pale yellow surrounding agar, the asymmetrical and divaricate biverticillate penicilli, the smooth or nearly so conidiophore, the divergent arrangement of branches and metulae, the loosely compact arrangement and gradually tapering sterigmata, and the ovate or subglobose conidia with walls smooth or nearly so.

However, they differ somewhat from the descriptions cited above in the ovate or subglobose conidia 2.8 to 3.8 μ in length, in the rather rapidly spreading growth, in the infrequent production of an abundant yellow mycelium, and in the rather yellow green conidial area.

Another culture, FAT 59, received in 1955 from the Sakaguchi Laboratory, University of Tokyo; as *Penicillium* PO 5, (their No. P-Naka-1-9) duplicated almost exactly the description of *P. miczinskii* as given above.

* Zaleski, K., Bul. Acad. Polonaise Sci.; Math. et Nat. Ser. B., pp. 482-484, Taf. 46 and 53 1927.

** Thom, C., The Penicillia, pp. 488-489. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 309-312. 1949.

P. nalgiovensis Laxa.

FAT 1489, 170.

The colony characteristics and microscopic characters are shown in Tables C-9 and M-9, respectively.

The strains are assigned to *P. nalgiovensis* Laxa (1932*; Raper, Thom

and Fennell,** 1949) because of the restricted character of growth, the somewhat floccose or deeply velutinous colonies, the blue-gray green colors of conidial areas, the orange-red or red-brown shades of the reverse, the orange pigmentation of the surrounding agar, the asymmetrical biverticillate and divaricate penicilli, the conidiophores with walls smooth or nearly so, up to 300 to 1000 μ in length, the divergent arrangement of branches and metulae, sterigmata of the acute type with conidium-bearing tips, compactly or loosely arranged, and the globose or subglobose conidia with walls smooth or nearly so.

However, they differ somewhat from the descriptions cited above in the blue green conidial areas, in the sterigmata mostly 6.2 to 8.7 μ in length, and in the conidia usually 1.5 to 3.2 μ in diameter.

Strain FAT 1489 was received in 1955 from Katura Laboratory, University of Niigata, as *P. expansum* (Link) Thom, and FAT 170 was received in 1449 from th Sakaguchi Laboratory, University of Tokyo (their No. P-4-7) as *P. expansum* (Link) Thom.

* Laxa, O., Zentbl. f. Bakt. (II) 86: 160-165. 1932.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 319-322. 1949.

P. echinulo-nalgiovense Abe.

FAT 907, 884.

The colony characteristics and microscopic characters are shown in Tables C-9 and M-9, respectively. A colony's photograph and an electron micrograph are shown in Figs. C-12 and M-21, respectively.

Colonies on Czapek agar grow rather restrictedly, attaining a diameter of 36 to 37 mm. in 10 to 12 days at 25°C, veltutinous or subfloccose, consisting of a fairly close network of vegetative mycelia bearing crowded conidial structures; radially furrowed, with a white or pale yellow margin 1.0 to 2.0 mm. wide; conidial areas in olive or yellow green shades near Olive Green or Lincoln Green, becoming Citrine Drab with age; exudate lacking or limited, colorless; odor limited, moldy; reverse in typical reddish shades near Maroon, Victoria Lake or Hay's Maroon, with surrounding agar in pale yellow or light reddish shades; conidiophores arising primarily from the substratum or from basal felt, and sometimes from aerial hyphae, variable in length, commonly up to 60 to 190 or 380 μ long by 2.5 to 3.3 μ in diameter, typically rough-walled, and with apices 3.0 to 4.4 μ in diameter; penicilli biverticillate, asymmetrical and strongly divaricate, consisting variously of occasional branches, metulae and sterigmata, with branches and metulae varying markedly in arrangement and in size; branches variable, commonly 10.0 to 20.0 or 25.0 μ in length by 2.0 to 3.2 μ in diameter, metulae typically divergent, 9.3 to 15.6 or 20.0 μ by 2.1 to 3.2 μ; sterigmata in compact or loosely compact verticils of 3 to 6 or 7, mostly 8.5 to 10.4 or 12.5 μ by 2.1 to 3.4 μ, acute type; conidia ovate (near strawberry form) or subglobose, mostly 2.5 to 3.8 μ, typically echinulate or verruculose walled;

conidial chains usually columnar or loosely tangled up to 30 to 70 or 130 μ in length; and conidia with echinulate or verruculose walls as seen in electron microscopy. Colonies on steep agar rather more rapidly than on Czapek agar, 47 to 48 mm. in diameter in 10 to 12 days at 25°C; the other characters are as described above.

However, these strains differ markedly from *P. nalgiovensis** Laxa (1932), primarily in the usually ovate form of conidia with echinulate or verruculose walls and in the conidiophores mostly 60 to 380 μ in length.

The strains also differ markedly from *P. nigricans* (Bainier) Thom** (1930), primarily in the olive green or dull yellow green colors of conidial areas, in the strongly reddish colors of the reverse, and in the ovate form of the conidia.

Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characterizes the above strains.

The author, therefore, regards the cultures in question as representing a new species, to which the binomial *Penicillum echinulo-nalgiovense* Abe is applied. The specific name is taken from the Latin, *echinulo-nalgiovense* (meaning echinulate and resembling nalgiovensis), and is applied because of the character of conidia wall and the resemblance to *P. nalgiovensis* in the characters of colonies and penicilli. The species clearly belongs in the Biverticillata-Asymmetrica section and is most satisfactorily assigned to be series with *P. nalgiovensis* Laxa (1932), as in the classification of Raper, Thom and Fennell*** (1949).

* See, *P. nalgiovensis* Laxa.

** See, *P. nigiricans* (Bainier) Thom.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Pencillia, 1949.

P. canescens Sopp.

FAT 832.

The colony characteristics and microscopic characters are shown in Tables C–9 and M–9, respectively.

The strain is assigned to *P. canescens* Sopp (1912*; Thom, 1930**; Raper, Thom and Fennell,*** 1949) because of the subfloccose character of its colonies, the radially broadly furrowed colonies, the blue green shades in the margin and dark yellow green shades in the center of its conidial areas, the violet colors at first, becoming yellow or vinaceous and brown, in the reverse, the violet color becoming dull light brown in the surrounding agar, the asymmetrical and biverticillate and divaricate, occasionally irregular, penicilli, the granular walls of its conidiophores, the rough-walled and divergent arrangement of its branches and metulae, the compact or loose arrangement of sterigmata, acute type with narrow conidium-bearing tips, the globose or subglobose conidia with rough walls, the columnar or loosely tangled conidial chains, and the conidia with delicately echinulate or

verruculone walls as shown in electron microscopy (Fig. E-22).

However, the strain differs more or less from the descriptions cited above in the rather broadly spreading character of growth, in the violet pigmentation at first of reverse and surrounding agar, and also in the conidia, mostly 2.1 to 3.0 μ in diameter.

* Sopp, O., Monogr. pp. 181–182, Taf, XIX, fig. 136; Taf. XXIII, fig. 28. 1912.

** Thom, C., The Penicillia, pp. 347–348. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 316–319. 1949.

P. jenseni Zaleski.

FAT 770.

The colony characteristics and microscopic characters are shown in Tables C-9 and M-9, respectively.

The strain is assigned to *P. jenseni* Zaleski (1927*; Thom, 1930**; Raper, Thom and Fennell,*** 1949) because of the restricted character of its growth, the subfloccose colonies, the yellow green shades, becoming Tea Green of its conidial areas, the colorless or dull yellow reverse, the colorless surrounding agar, the smooth or nearly so walls of its conidiophores, the asymmetrical and strongly divaricate, biverticillate penicilli, the divergent arrangement and variable size of its branches and metulae, the loosely compact arrangement of sterigmata of the acute type, the globose to subglobose conidia with delicately echinulate walls, and the loosely columnar form of its conidial chains.

However, the strain differs somewhat from the descriptions cited above in the near Sage Green or Pea Green, becoming Tea Green, conidial areas and in the colorless or yellow reverse.

Another culture, FAT 1360, received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, as *P. olivaceum Wehmer*, (their No. 6014) duplicated almost exactly the description of *P. jenseni* as given above.

* Zaleski, K., Bul. Acad. Polonaise Sci.: Math. et Nat. Ser. B, pp. 494–495, Taf. 57. 1927.

** Thom, C., The Penicillia, pp. 346–347. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 322–323. 1949.

P. nigricans (Bainier) Thom.

FAT 948.

The colony characteristics and microscopic characters are shown in Tables C-9 and M-9, respectively.

The strain is assigned to *P. nigricans* (Bainier) Thom (1930*; Raper, Thom and Fennell,** 1949) because of the restricted character of its growth, the typically velvety colonies, the dark grayish olive conidial area,

the orange red reverse, the yellow orange surrounding agar, the asymmetrical and strongly divaricate biverticillate penicilli, the conidiophores variable in length with walls smooth or nearly so, the metulae and branches variable in length and strongly divergent, the more or less divergent arrangement and acute type of its sterigmata, the globose conidia with aculeate walls and the parallel, tangled or divergent conidial chains.

However, the strain differs somewhat from the descriptions cited above in the diameter in 10 to 12 days at 25°C on Czapek agar about 22 mm., in the typically radially furrowed and velvety colonies, and also in the conidia mostly 2.3 to 3.1 μ in diameter, with typically aculeate walls.

* Thom, C., The Penicillia, pp. 351–353. 1930.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 325–329, 1949.

P. nigricans Thom var. *sulfuratum* Abe.

FAT 536.

The colony characteristics and microscopic characters are shown in Tables C–9 and M–9, respectively. A colony's photograph and an electron micrograph are shown in Fig. C–13 and E–23, respectively.

Colonies on Czapek agar grow rather rapidly, attaining a diameter of about 43 mm. in 10 to 12 days at 25°C, consisting of a comparatively deep basal felt bearing crowded conidial structures, subfloccose, with surface typically broadly radially furrowed, with a white margin 1.0 mm. wide, conidial areas in dark dull green near Dark Ivy Green, becoming Dark Grayish Olive with age; exudate lacking; odor strong, suggesting certain species of *Actinomyces*; reverse pale yellow, becoming pink surrounding agar colorless, becoming pale pink; conidiophores airising primarily from the substratum or from the basal felt, occasionally from aerial hyphae, variable in length, commonly 60 to 250 μ long by 2.5 to 3.1 μ in diameter, with walls smooth or nearly so, with apices 3.1 to 4.4 μ in diameter; penicilli biverticillate, asymmetrical and strongly divaricate, with branches and metulae varying markedly in arrangement and in size; branches variable, commonly 10.2 to 26.4 μ by 2.5 to 3.3 μ; metulae typically strongly divergent, mostly 9.3 to 18.7 μ by 2.5 to 3.4 μ, in verticils of 2 to 4; sterigmata in somewhat divergent verticils of 5 to 8, mostly 6.2 to 8.7 μ by 1.8 to 3.0 μ, acute type; conidia typically globose to subglobose and walls typically aculeate, mostly 2.5 to 3.4 μ; conidial chains loosely parallel or tangled, up to 30 to 90 μ in length; and conidia showing typically aculeate walls in electron microscopy.

Colonies on steep agar growing rather rapidly, about 45 mm. in 10 to 12 days at 25°C, conidial areas are typically Slate Olive becoming Dark Grayish Olive, and reverse becoming brownish; the other characters are as described above.

However, this strain differs markedly from *P. nigricans* Thom* (1930), primarily in the rather rapidly spreading character of its growth, in the

subfloccose colonies, and in the yellow color, becoming pink, of its reverse, in the metulae mostly 9.3 to 18.7 μ in length, and in the typically aculeate walls of its connidia.

The strain also differs markedly from *P. albidum*,** *P. kapuscinskii*,*** *P. melinnii***** and *P. raciborskii*,***** primarily in the typically smooth conidiophore walls, in the conspicuously aculeate walls of its conidia, and the typically olive conidial areas.

Therefore, since it cannot be satisfactorily assigned to any other described form, the author consider this strain a new variety to which the name *P. nigricans* Thom var. *sulfuratum* Abe is assigned.

*,**** See, *P. nigricans* (Bainier) Thom, and *P. melinii* Thom.

** Sopp, O., Monograph, pp. 186–187, 1912; Thom, C., The Penicillia, pp. 350–351. 1930; Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 329–330. 1949.

*** Zaleski, K., Bul. Acad. Polonaise Sci.; Math et Nat. Ser. B, pp. 484–485. 1927.; Thom, C., The Penicillia, pp. 355–356. 1930.; Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, p. 330.

***** Zaleski, K., Bul. Acad. Polonaise Sci.: Math. et Nat. Ser. B, pp. 484–485. 1927.; Thom, C., The Penicillia, pp. 318–319. 1930.; Raper, K. B., Thom, C. and Fennell, D. I., cited above., pp. 333–334. 1949.

P. melinii Thom.

FAT 581, 992.

Toe colony characteristics and microscopic characters are shown in Tables C–9 and M–9, respectively. An electron micrograph is shown in Fig. E–24.

The strains are assigned to *P. melinii* Thom (1930*; Raper, Thom and Fennell,** 1949) because of the velutinous or subfloccose colonies, typically radially furrowed and raised in the central or subcentral areas, the yellow green or dull green, quickly becoming grayish olive, conidial areas, the yellow-orange or dull yellow reverse, the colorless or strongly yellow surrounding agar, the typically granular or tuberculate walled conidiophores, the asymmetrical and strongly divaricate biverticillate penicilli, the strongly divergent arrangement and variable size of branches and metulae, the somewhat divergent arrangement of sterigmata of the acute type with abruptly narrowed tips, the typically aculeate walled and globose conidia and the loosely tangled and divergent conidial chains.

However, the strains differ more or less from the descriptions cited above in the rather rapidly spreading character of growth, and in the conidia mostly 1.8 to 3.0 μ in diameter.

* Thom, C., The Penicillia, p. 273. 1930.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Pencillia, pp. 331–332. 1949.

Velutina sub-section.

P. citrinum Thom.

FAT 517, 251, 972, 1131, 1039, 219, 513, 116, 696, 600, 607, 515, 518, 1275, 523, 537, 540, 556, 608, 93, 134, 801, 254, 821, 538, 541, 361, 973, 975, 332, 333.

The colony characteristics and microscopic characters are shown in Tables C–10 and M–10, respectively.

The strains are assigned to *P. citrinum* Thom (1910, 1930*; Raper, Thom and Fennell,** 1949) because of the somewhat restricted or rapid character of growth, the typically velvety colonies, the production of bright yellow to orange or orange brown, and sometimes pinkish shades, in reverse and surrounding agar, the typically biverticillate and asymmetric penicilli, seldom producing of branches, the conidiophores with smooth or nearly so walls, the compact or somewhat divergent metulae with apices usually enlarged, sterigmata of the acute type, the typically globose conidia with smooth walls or nearly so, and also the chains of conidia in well-defined columns. These strains are clearly separated into the following types on the basis of color of colonies, pigments developed in the colony reverse and surrounding agar, and also the characters of the colony surface: the first type is characterized particularly by the typically furrowed, bluish green colonies, the bright yellow colors at first, becoming orange, in the revsere, and also the usually strong yellow pigmentation of the agar surrounding the colony. The second is distinguished by the typically radially furrowed colonies, the dull green colonies, becoming olivaceous black, the yellow shades, changing to light brownish, in the reverse, and also by the pale yellow color, becoming pale orange, of the agar surrounding the colony. The third is characterized by the typically radially furrowed colonies, by the blue or yellow green colonies, becoming grayish olive, the dull yellow or slightly vinaceous colors in the reverse, and the typically pinkish color of the surrounding agar. The fourth type is by the infrequent production of radially furrowed colonies, by the typically dark yellow green colonies, the bright yellow shades, becoming orange, in the reverse, and also by the bright yellow color, becoming orange of the surrounding agar. The fifth is characterized particularily by the infrequent production of radially furrowed colonies, the dull yellow green colony color, and also the pale yellow color of the reverse and agar (strongly yellow on Czapek and steep agar slants). The sixth type is recognized by the slightly furrowed colonies, their dark yellow green color, and the dull yellow colors in the reverse and surrounding agar (strong yellow on Czapek and steep agar slants).

However, these strains differ somewhat from the above-listed descriptions in the rate of growth, in the color character of colonies, in the pigmentation of the reverse and agar, and also in details of the size of the

penicilli, as described above. Other culture, FAT 1337, 1342, 1344, 1346, 1382 and 1393, received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, (their Nos. 6027, 6048, 6004, 6010, 6019, and 6024) as *P. lividum* Westling, *P. roseo-purpureum* Dierckx, *P. baiiolum* Bainier, *P. citrinum* Thom, *P. fusco-glaucum* Biourge var. and *P. humicola* Oudemans, duplicate almost exactly the description of *P. citrinum* Thom as given above.

In addition, strains FAT 1441, 1442, 1443, 1445 and 1450, received in 1955 from Prof. J. Fukumoto, University of Osaka, P. *glaucum* Link, penicillin producing mold 19 and NaO 2; FAT 1474 and 1482, received in 1955 from Prof. M. Kimata, Microbiological Laboratory, University of Kyoto, as *Citromyces* cesiae Bainier and *P. glaucum* Link; FAT 1322, received in 1955 from Mr. I. Kanai, Department of Central Research Institute, Japan Monopoly Corporation, Tobacco Research, (their No. 15 (Ti 1)); FAT 1487, received from Prof. Y. Tomiyasu, University of Kyushu, as *P. chrysogenum* Thom; FAT 1409, received in 1955 from Department Agricultural Chemistry, University of Kagoshima, as *P. glaucum* Link; FAT 187, 182, 189, 173, 165 and 55, received in 1955 from the Sakaguchi Laboratory, University of Tokyo, (their Nos. P-5-3, P-5-6, P-5-7, P-5-9 and P-5-10 and P-Nakazawa-1-5) as. *P. oxalicum* KU, *P. luteum* (1), *P. purpurogenum* Stoll, *P. glaucum* Link, *P. citrinum* (Boarn) and *Citromyces* Sn C; FAT 1419 and 1415, received in 1955 from Prof. M. Oda, University of Osaka, as P. *fusco-glaucum* Biourge var. and *P. roseo-purpureum* Dierckx; and FAT 1463 and 1462, received in 1955 from Mr. T. Hasegawa, Institute for Fermentation, Osaka, (their No. 4631 and 4641) as *P. citrinum* Thom and *P. notatum* Westling duplicated almost exactly the description of *P. citrinum* Thom as presented above.

* Thom, C., U. S. Dept. Agr. Bur. Anim. Ind., Bull. 118, pp. 61-63, fig. 22. 1910, Op. cit. pp. 256-257, fig. 34. 1930.

** Raper, K. B., Thom, C. and Fennell, D. I. Op. cit. pp. 345-350. 1945.

P. steckii Zaleski.

FAT 509, 105, 501, 510, 511, 98, 714, 713, 805, 802, 181, 717, 715, 716, 1041, 1063; 979, 986, 935.

The colony characteristics and microscopic characters are shown in Tables C-10 and M-10, respectively.

These strains are assigned to *P. steckii* Zaleski (1927*; Thom, 1930**; Raper, Thom and Fennell,*** 1949) because of the rather restricted or somewhat rapidly spreading growth, the typical velvety or velutinous colonies, the yellow green or dull green colony color, the colorless or dull yellow, becoming grayish olive or olive, pigmentation in reverse, the colorless or sometimes pale yellow pigmentation of the agar surrounding the colony, the typical biverticillate and asymmetric penicilli, the infrequent production of branches, the unbranched conidiophores with walls smoth or nearly so, the

somewhat suggestive divaricate and occasionally irregular arrangement of the metulae, the acute type sterigmata in a compact or parallel arrangement and the typically globose to subglobose conidia with smooth walls or nearly so, usually less than 2.5 μ long.

The strains may be easily separated into the following four types, on the basis of colony colors, pigment developed in the reverse and the surrounding agar, and also in the characters of the colony surface: the first type is characterized particularly by yellow green shades in the marginal area and dull green shades in the central areas of the colonies, by the colorless or pale yellow shades in reverse, and also by the colorless agar surrounding the colony. The second is distinguished by the shallow, radially furrowed colonies, near Pea Green in the marginal areas, Dark Ivy Green in the central area, and resembling the first type in the reverse and surrounding agar. The third is marked by yellow green colonies, becoming dark olive or dark olivaceous, slightly radially furrowed with a pale yellow to pale olive cast in the reverse and colorless agar surrounding the colony. The fourth type is characterized by sulcate and radially furrowed colonies in yellow green shades, by the pale yellow or pale brownish shades, becoming light brownish, in the reverse, by the colorless agar surrounding the colony and by the usually somewhat divaricate and irregular arrangement of the metulae.

However, these strains differ somewhat from the descriptions cited above in the rate of growth and in the color of the colonies, as described above.

Another culture, FAT 181, received in 1955 from the Sakaguchi Laboratory, University of Tokyo, (their No. P-5-5) as *P. luteum* (Baarn), duplicates almost exactly the description of FAT 805 as presented above.

* Zaleski, K. Bul. Acad. Polonaise Sci.: Math. et Nat. Ser. B, pp. 469–471; Taf. 50. 1927.

** Thom, C. Op. cit., pp. 255–256. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I. Op. cit., pp. 350–352, 1949.

P. citreo-virens Abe.*

FAT 319, 320.

The colony characteristics and microscopic characters are shown in Tables C–10 and M–10, respectively. A colony's photograph and an electron micrograph are shown in Figs. C–14 and M–25, respectively.

Colonies on Czapek agar grow rather rapidly, attaining a diameter of 47 to 49 mm. in 10 to 12 days at 25°C, consisting of a somewhat compact basal felt, appearing typical velevety, with a white margin about 1.0 mm. wide, smooth, sporulating abundantly in bright yellow green shades near Empire Green, becoming Cress Green with age; exudate lacking; odor limited or indefinite, moldy; reverse usually in cream shades; becoming typically green-olive in the central area and sepia in the marginal areas; surrounding agar usually colorless; conidiophores arising mostly from the

substratum or from basal felt, mostly 60 to 250 μ in length by 2.5 to 2.7 μ in diameter, with apices 2.8 to 4.7 μ in diameter and with walls smooth or nearly so, usually unbranched; penicilli typically biverticillate and asymmetrical, consisting of a terminal group of 3 to 5 compact or slightly divergent metulae that measure about 12.5 to 25.0 μ by 2.5 to 3.7 μ (apices commonly enlarged to 2.6 to 4.7 μ), each supporting a cluster of 3 to 7 compact or parallel sterigmata measuring about 7.5 to 11.9 μ by 1.7 to 2.5 μ, and bearing conidia in columns or loosely tangled chains up to 60 to 120 μ in length; conidia globose to subglobose, mostly 2.3 to 3.3 μ, smooth-walled or nearly so; and conidia walls delicately roughened (spines less than 0.1 μ) as shown in electron microscopy.

Colonies on steep agar grow rather rapidly, up to 42 to 47 mm. in 10 to 12 days at 25°C, colonies are loosely radially furrowed, and reverse is in typical olive green shades; the other characters are as described above.

Colonies on Koji-extract agar are similar to steep and Czapek agar, but typical in dusky olive green shades in reverse that characterized it.

These strains differ markedly *P. citrinum* Thom** (1910, 1930; Raper, Thom and Fennell, 1949) in the longer (12.5 to 25.0 μ) metulae, in the typical green color in reverse on Czapek and steep or Koji-extract agar, and also the bright yellow green colony color. They also differ from *P. steckii* Zaleski*** (1927; Thom, 1930; Raper, Thom and Fennell, 1949) primarily in the compact or slightly divergent arrangement of the metulae, in the typical green color in reverse and the size of conidia.

Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characterized the above strains. The author, therefore, considers them as representing a new species to which the binomial *P. citreo-virens* Abe is assigned.

The specific name is taken from the Latin, *citreo-virens* (meaning near citron-green), and is applied because of the typical pale green color of reverse on Czapek agar. The correct placement of the species remained in doubt, but it appears to be most satisfactorily assignable to a series with *Penicillium citrinum* Thom in the Velutina subsection of the Asymmetrica as in the classification of Raper, Thom and Fennell.

* Abe, S. Paper read before the Agr. Chem. Soc. Japan (Tokyo). Oct. 1952.

** See, *P. citrinum* Thom.

*** See, *P. steckii* Zaleski.

P. corylophilum Dierckx.

FAT 706, 595, 644, 1090, 1041.

The colony characteristics and microscopic characters and shown in Tables C–10 and M–10, respectively.

The strains are assigned to *P. corylophilum* Dierckx (1901*; Biourge,** 1923; Thom, 1930***; Raper, Thom and Fennell,**** 1949) because of the restricted character of growth, the typically velvety or slightly subfloccose

colony texture, the blue green or yellow green colony colors, the brownish color in reverse, the typically biverticillate and asymmetric penicilli, the infrequent production of branches, the smooth or nearly so conidiophore walls, the more or less unequal length of the metulae, sterigmata of the acute type, the elliptical to subglobose conidia with walls smooth or nearly so, the tangled, loosely parallel or loosely columnar chains of conidia.

However, these strains differ somewhat from the earlier descriptions (cited above): FAT 706, 595 and 644, have a colony surface smooth or slightly radially furrowed, exudate limited or abundant, in yellow or pink shades, the metulae 2 or sometimes 3 and somewhat divergent; strains FAT 1090 and 1041, have colonies typically radially furrowed, conidial areas in yellow green shades, exudate abundant, in dull yellow colors, metulae numbering 3 to 5, compact or loosely compact, and usually 10.6 to 18.6 μ in length.

Other cultures, FAT 61, FAT 62 and FAT 65, received in 1955 from the Sakaguchi Laboratory, University of Tokyo, as their Nos. P–Nakazawa 2–1, 2–2 and 2–5, duplicated almost exactly the description of *P. corylophilum* as given above.

* Dierckx, R. P., Soc. Sci. Brux. 25: 86. 1901.

** Biourge, Ph., Monograph. La Cellule 33: fasc. 1, pp. 266–267; Col. Pl. IX and Pl. XIV, fig. 83. 1923.

*** Thom, C., The Penicillia, pp. 254–255. 1930.

**** Raper, K. B., Thom, C. and Fennell, D. I., Op. cit., pp. 341–345. 1949.

P. corylophiloides Abe.*

FAT 306, 984, 862, 308.

The colony characteristics and microscopic characters are in shown Tables C–10 and M–10, respectively. A colony's photograph and an electron micrograph are shown in Figs. C–15 and M–26, respectively.

Colonies on Czapek agar grow rather restrictedly, attatining a diameter of 2.7 to 3.2 mm. in 10 to 12 days at 25°C, consisting of somewhat compact basal felt, typically velvety, with a white narrow margin 0.2 to 0.3 mm. wide, smooth or slightly furrowed, sporulatiag abundantly in dull yellow green shade near Dark Greenish Glaucous, American Green or Pistachio Green, becoming Dusky Olive Green or Andover Green with age; exudate abundant, colorless; reverse at first colorless or pale yellow, becoming pale olive, with surrounding agar colorless; penicilli typically biverticillate and asymmetrical, seldom producing branches; conidiophores arising mostly from the substratum, or from basal felt, mostly 130 to 180 μ length by 2.5 to 3.2 μ diameter, with apices enlarged, 3.4 to 4.7 μ in diameter, smooth walled or nearly so usually unbranched; metulae in a terminal verticil of 4 to 5 or occasionally 8, variable in length, mostly 12.5 to 18.7 μ by 2.5 to 3.4 μ, each supporting a group of 5 to 8 sterigmata measuring about 10.0 to 11.9 μ by 2.0 to 2.8 μ, typieally acute type and smooth walled or nearly so; coni-

dia elliptical to subglobose, mostly 2.5 to 3.4 μ by 2.0 to 2.6 μ, with smooth walls or nearly so; chaines of conidia in tangled or loose columns, up to 60 to 90 μ in length; conidia showing delicately rough walls in electron microscopy.

Colonies on steep agar grow somewhat rapidly, up to 34 to 43 mm. in 10 to 12 days at 25°C; colonies broadly radially furrowed; the other characters are as described above. These strains differ markedly from *P. corylophilum* Dierckx, primarily in the colorless or pale yellow colony reverse, in the 4 to 8 terminal verticils of the metulae, and in their length (12.5 to 18.7 μ).

They also differ markedly from *P. paxilli* Bainier*** primarily in the unequal lengths of the rather long metulae, and from *P. steckii* Zaleski**** and *P. citrinum****** Thom primarily in the typically elliptical conidia.

Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characterizes the above strains. The author, therefore consider them as representing a new species to which the binomial *P. corylophiloides* Abe is assigned.

The specific name is taken from the Latin, *corylophiloides* (meaning corylophilum-like), and is applied because of the elliptical form of the conidia.

The correct placement of the species remains in doubt, but it appears to be most satisfactorily assignable to a series with corylophilum Dierckx in the Velutina subsection of the Asymmetrica, as in the classification of Raper, Thom and Fennell.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo), Oct. 1952.

** to *****, See, Each species.

P. paxilli Bainier.

FAT 1286.

The colony characteristics and microscopic characters are shown in Tables C–10 and M–10, respectively.

The strain is assigned to *P. paxilli* Bainier (1907*; Thom, 1930**; Raper, Thom and Fennell,*** 1949) because of the more or less restricted character of its growth, the typically velvety colonies, the dark or dull green shades of its conidial areas, the dull yellow pigmentation of its reverse, the biverticillate and symmetrical penicilli, seldom producing branches, the numerous verticils and compact arrangement of metulae of equal length, the compact arrangement of its sterigmata of acute type, the elliptical or ovate form of conidia with walls the smooth or nearly so.

The strain was received in 1952 from Prof. K. Sakaguchi, University of Tokyo, originally sent from Drs. K. B. Raper and D. I. Fennell, University of Wisconsin, (their NRRL 2008) as *P. paxilli* Bainier.

* Bainier, G., Bul. Soc. Mycol. France 23: 95–96; Pl. X, figs. 1–4. 1907.

** Thom, C., The Penicillia, pp. 294–296. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., Op. cit., pp. 414–416. 1949.

P. chrysogenum Thom.

FAT 1054, 917. 1020, 349, 514, 914, 533, 508, 1265.

The colony characteristics and microscopic characters are shown in Tables C–11 and M–11, respectively.

The strains are assigned to *P. chrysogenum* Thom (1910,* 1930; Biourge, 1923**; Westling, 1911***; Raper, Thom and Fennell,**** 1949) because of the rather rapid growth, the typically velvety or velutinous colonies, the typically radially furrowed colonies, yellow green or blue yellow green in color, the bright or light yellow or brownish pigmentation of the reverse, the typical yellow color and broad pigmentation of the agar surrounding the colony; the smooth-walled or nearly so, unbranched conidiophores, the biverticillate and asymmetrical penicilli, the compact or loosely compact arrangement of metulae, the compact sterigmata of the acute type, the typically conidia with walls smooth or nearly so, and well-defined columnar form of the chains of conidia.

The strains are clearly separable into three types (shown in Tables C–11 and M–11) on the basis of colony color, pigments developed in the reverse and surrounding agar, in the characters of the colony surface, and the length of its metulae.

However, these strains differ somewhat from the descriptions listed above in the typically brownish shades (in some strains) of the colony reverse, localized in the central area.

Other cultures, FAT 1472 and FAT 1352 were received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, (their Nos. 6294 and 6008 as *P. camerunense* Heim and *P. chlorophaeum* Biourge; FAT 1478 was received in 1955 from Microbilogical Laboratory, University of Kyoto, (their No. P–2), as *P. notatum* Westling; FAT 441 and FAT 448 and FAT 458 were received in 1955 from the Sakaguchi Laboratory, University of Tokyo, (their Nos. P–7–6, P–8–3 and P–9–1), as *P. notatum* Westling; these strains duplicated almost exactly the descriptions of *P. chrysogenum* as given above.

Conidia ovate to subglobose; FAT 658, 854, 544, 506, 855, 919, 853, 700.

These strains are characterized particularly by the ovate form of their conidia, by the infrequently radially furrowed colonies, by the bright or pale yellow pigmentation of the reverse and agar, by penicilli larger than described above, and by the broad character of their growth.

They also usually produced penicillin, 30 to 60 units per ml., on corn-steep-lactose medium in submerged culture when newly isolated from soil.

The strains are regarded as intermediate between *P. chrysogenum* and *P. notatum* in conidial form. They are assigned to *P. chrysogenum* Thom (cited above) because of the production of the near elliptical form of their conidia, and the other characters as described above, although the correct placement of the strains remains in doubt. The conidia in electron microscopy show ovate form and delicately roughened (Fig. E–27).

* Thom, C., U. S. Dept. Agr., Bur. Anim. Ind., Bull. 118, pp. 58–60, fig. 20. 1910; The Penicillia, pp. 261–262. 1930.

** Biourge, PH., Monograph, La Cellule 33: fasc. 1, pp. 170–172, Col. Pl. IV and Pl. VI, fig. 32. 1923.

*** Westling, R., Arkiv. f. Bot. 11: 54, 107–108, figs. 23 and 64. 1911.

**** Raper, K. B., Thom, C. and Fennelll, D. I., Op. cit., pp. 359–364. 1949.

P. chrysogenum Thom mut. *fulvescens* Takashima, Arima and Abe.*

FAT 515.

The colony characteristics and microscopic characters are shown in Tables C–11 and M–11, respectively. A colony's photograph and an electron micrograph are shown in Figs. C–16 and E–28, respectively.

Colonies of the mutant grown on Czapek and steep agar differ from the original species in the entire absence of green color. This strain was obtained by Takashima and Arima as a mutant from a normal green strain of *P. chrysogenum* Thom (FAT 514) by ultra-violet radiation. Therefore, we recognize the strain as a new variety to which the name *P. chrysogenum* Thom mut. *fulvescens* Takashima, Arima and Abe is assigned because of the cinnamon color of its colonies.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo), Oct. 1952.

P. meleagrinum Biourge.

FAT 1222.

The colony characteristics and microscopic characters are shown in Tables C–11 and M–11, respectively.

The strain is assigned to *P. meleagrinum* Biourge (1923*; Thom, 1930**; Raper, Thom and Fennell,*** 1949) because of the rapidly spreading and velutinous colonies, radially furrowed and the dark yellow-green in color, the typical brownish pigmentation throughout in reverse, with colorless surrounding agar, the typically biverticillate and asymmetrical penicilli, the conidiophores smooth walled or nearly so and usually unbranched, the compact metulae, sterigmata of the acute type with compact arrangement, the typically elliptical conidia with walls smooth or nearly so, and also the abundant production of colorless exudate.

However, the strain differs somewhat from the descriptions listed above in the length and width of all elements of the penicilli, as described in Table M–11.

* Biourge, PH., Monograph., La Cellule 33; fasc. 1, pp. 147–149; Col. Pl. III and Pl. IV, fig. 22. 1923.

** Thom, C., Op. cit., 266–267, 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., Op. cit., pp. 364–367. 1949.

P. meleagrinum Biourge var. *viridi-flavum* Abe.*

FAT 525, 652, 803, 823, 930, 1013, 1255, 1259.

The colony characteristics and microscopic characters are shown in

Tables C–11 and M–11, respectively. A colony's photograph and an electron micrograph are shown in Figs. C–17 and E–29, respectively.

Colonies on Czapek agar grow rapidly, attaining a diameter of 41 to 53 mm. in 10 to 12 days at 25°C, consisting of a comparatively thin basal felt bearing crowded conidial structures; some strains velvety, and other strains lightly subfloccose; sometimes zonate, with central area often somewhat raised, in some strains smooth; with a white margin 1.0 to 1.5 mm. wide; conidial areas in gray blue green shades in marginal areas and dull yellow green shades in central or subcentral areas, becoming quickly near Andover Green, Vetiver Green throughout with age; exudate lacking or limited, colorless; odor limited, moldy; reverse in dull yellow to pale brownish shades, with surrounding agar usually uncolored; conidiophores arising primarily from the substratum or from basal felt, variable in length, commonly up to 120 to 320 μ in length by 2.1 to 3.8 μ in diameter, with walls smooth or nearly so, and with apices enlarged to 2.8 to 5.0 μ in diameter; penicilli biverticillate and asymmetrical, commonly showing one or more branches in addition to the main axis, terminating in verticils of 2 to 5 metulae-bearing sterigmata; branches variable, commonly 9.3 to 31.0 μ in length by 2.1 to 3.8 μ in diameter; metulae usually 9.3 to 18.7 μ by 2.1 to 3.8 μ; sterigmata in fairly compact verticils of 4 to 8, mostly 8.1 to 10.0 μ by 1.8 to 2.6 μ, acute type; conidia elliptical to subglobose, mostly 2.1 to 3.0 μ by 1.7 to 2.6 μ, smooth walled or nearly so; conidial chains usually columns up to 60 to 190 μ in length, and conidia show delicately roughened walls in electron microscopy. Colonies on steep agar grow rapidly, 54 to 68 mm. in 10 to 12 days at 25°C, smooth or slightly radially furrowed; some strains typically radially furrowed; conidial area quickly in olive brown or gray olive shades, reverse typicaly brownish shades; the other characters are as described above.

These strains differ from *P. meleagrinum* Biourge** (1923, Thom, 1930; Raper, Thom and Fennell, 1949) primarly in the length (2.1 to 3.0 μ) of conidia, in the colonies quickly becoming dull green, in the longer metulae and branches, and in the fact of luxuriantly growth on Sakaguchi and Wang agar.

The strains also differ from *P. chrysogenum* Thom*** primary in the pigments developed in the colony reverse and the size of conidia as described above.

Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characterizes the above strains.

The author, therefore, considers them as representing a new variety to which the name *P. meleagrinum* Biourge var. *viridi-flavum* Abe is assigned.

The varietal name is taken from the Latin, *viridi-flavum* (meaning green-yellow), and is applied because of near Andover Green color of its colonies.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo), Oct. 1952.

** See, *P. meleagrinum* Biourge.

*** See, *P. chrysogenum* Thom.

P. notatum Westling.

FAT 1079, 577, 578, 532, 528, 530, 918, 993, 863, 612, 616, 574, 522, 519, 865, 529, 357, 520, 618, 579, 350, 980, 547, 545.

The colony characteristics and microscopic characters are shown in Tables C–11 and M–11, respectively.

These strains are assigned to *P. notatum* Westling (1911*; Biourge, 1923**; Thom, 1930***; Raper, Thom and Fennell,**** 1949) because of the rather rapid and broady character of growth, the typically velvety or velutinous colonies, the conspicuously or typically radially furrowed colonies, the yellow-green or blue-green shades of the conidial areas, the yellow shades thoughout or sometimes brownish shades localized in the central or subcentral areas of the reverse, the typical yellow pigmentation of the surrounding agar, the biverticillate and asymmetrical penicilli, the smooth-walled or nearly so and unbranched conidiophores, the compact or loosely compact arrangement of metulae, the compact or loosely parrellel arrangement of sterigmata of the acute type, the typically globose to subglobose conidia with walls smooth or nearly so, and the columnar or loosely tangled form of conidial chains.

The strains are clearly separable into four types on the basis of colony color, the pigments developed in the reverse and surrounding agar, the production of exudate, and the width and length of the penicilli and conidiophores.

However, these strains differ somewhat from other descriptions given above in the typical yellow-green shades of their colonies (FAT 1079, 577, 578) in the matulae, 6.2 to 12.0 μ in length (FAT 612, 616, 574, 522, 519, 865) and in conidiophores, 5.0 to 6.8 μ in diameter (FAT 532, 528, 530, 918, 993, 863, 529, 357 and FAT 520, 618, 579, 350, 980, 547, 545). Other cultures, FAT 1476 and FAT 1481 were received in 1955 from Microbiological Labortory, University of Kyoto, (their Nos. P 1108 and P 1113), as *P. chrysogenum* Thom and *P. digitatum* Saccardo; FAT 1488 was received in 1955 from Prof. Y. Tomiyasu, University of Kyushu, as *P. granulatum* Bainier; FAT 1406 and FAT 1404 were received in 1955 from Dr. Y. Kinoshita, University of Niigata, as a *Penicillium* isolated from Uzuriba, and *P. expansum* (Link) Thom; FAT 1410 was received from Prof. T. Nakayama, Medical College of Osaka, as *P. notatum* Westling, P 233; FAT 1454 was received in 1955 from University of Kyushu, as *P. notatum* Westling; FAT 1443, 1437, 1438 and 1436 were received in 1955 from Prof. J. Fukumoto, College of Osaka, (their Nos. 15 and 80 and NRRL 1249 B 21, NRRL 1978, B. 2) as unknowns and *P. notatum* Westling; FAT 1353 and FAT 1347, 1345 were received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, (their Nos. 6038, 6207 and 6288) as *P. notatum* Westling albino mutant (Kondo); FAT 436 to FAT 445 (except FAT 441) was received in 1955 from the Sakaguchi Laboratory, University of Tokyo, (their Nos. P–7–1 to P–7–10 (except P–7–6)), as *P. notatum* Westling; and FAT 426 to FAT 435 and FAT 446, 447

and 450 to 457 were received in 1955 from the Sakaguchi Laboratory, University of Tokyo, (their Nos. P-6-1 to P-6-10 and P-8-1, P-8-2, and P-8-4 to P-8-10) as *P. notatum* Westling; these duplicate almost exactly the description of *P. notatum* as given above.

* Westling, R., Arkiv. for Botanik 11: 55, 95-97, figs. 17, 59. 1911.
** Biourge, Ph., Monograph, La Cellule 33: fasc. 1, pp. 179-181, Col. Pl. IV and Pl. VIII, fig. 37. 1923.
*** Thom, C., The Penicillia, pp. 264-265. 1930.
**** Raper, K. B., Thom, C. and Fennell, D. I., Op. cit., pp. 367-371. 1949.

P. cyaneo-fulvum Biourge.

FAT 580, 635, 699, 573, 697, 596, 586, 1130, 539.

The colony characteristics and microscopic characters are shown in Tables C-11 and M-11, respectively.

These strains are assigned to *P. cyaneo-fulvum* Biourge (1923*; Thom,** 1930; Raper, Thom and Fennell, 1949***) because of the rather rapidly or broadly spreading growth, the typical velvety or velutinous colonies, (some strains subfloccose), the typically radially furrowed colonies, the yellow green or blue-grey green shades of the conidial areas, the colorless exudate and surrounding agar, the dull yellow or brownish color of the reverse, the biverticillate and asymmetrical penicilli, the conidiophores with smooth walls or nearly so, loosely compact or compact metulae, the compact clusters of sterigmata of the acute type, and the globose to subglobose conidia with walls smooth or nearly so.

The strains are clearly separable into three types (shown in Tables C-11 and M-11) on the basis of colors of colonies, pigments developed in the colony reverse, in the characters of colony surface, and in the length of the metulae.

The strains differ somewhat from the descriptions cited above in the diameter of conidia (2.1 to 3.8 μ), the dark yellow green colony color in some strain (FAT 1130 and 539), in the velvety or velutinous textures, and also in the length of the metulae (9.3 to 18.7 μ) in some strains (FAT 1130, 539).

Another culture, FAT 1355 received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, (their No. 6009) as *P. citreoroseum* Dierckx, almost exactly duplicates the description of *P. cyaneo-fulvum* Biourge as given above.

* Biourge, Ph., Monograph, La Cellule 33: fasc. 1. pp. 174-176; Col. Pl. IV, fig. 34. 1923.
** Thom, C., The Penicillia, p. 267. 1930.
*** Raper, K. B., Thom, C. and Fennell, D. I., Op. cit., pp. 371-373. 1949.

P. oxalicum Currie and Thom.

FAT 265, 258, 630, 1134, 1180, 1119, 524, 160, 834, 835, 1026.

The colony characteristics and microscopic characters are shown in Tables C-12 and M-12, respectively.

The strains are assigned to *P. oxalicum* Currie and Thom (1915*; Thom, 1930**; Raper Thom and Fennell,*** 1949) because of the broadly speading character of growth, the typically velvety or velutinous colonies, the darkish yellow green or olive-green conidial areas, the yellow shades throughout or greenish or yellow or orange shades localized in reverse, the biverticillate and asymmetrical penicilli, the smooth-walled or nearly so conidiophores, branches or metuale, sterigmata of the acute type with conidium-bearing tips more or less tapered, the strongly elliptical conidia with walls smooth or nearly so, and the columnar form of conidial chains.

The strains are clearly separable into three types (shown in Tables C–12 and M–12) on the basis of colony color, pigments developed in the colony reverse, and in the character of the colony margin.

However, they differ somewhat from the descriptions cited above in the production in some strains of a green pigmentation in the central area of the reverse, and in the production in soms strains of pale yellow or orange pink mycelia in the broad margin. In addition, these strain usually grow broadly or restrictedly at 37°C.

Other cultures, FAT 1361 and FAT 1359, received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, (their Nos. 6044 and 6013) as *P. puberulum* Bainier and *P. digitatum* Saccardo, almostly exactly duplicate the description of *P. oxalicum* as given above. In addition, FAT 775 received in 1953 from Dr. C. Miti, College of Ochanomizu, as *P. oxalicum* Currie and Thom var. *pectinovorum* Iwasaki, originally sent from Dr. Iwasaki, Nippon Agricultural Research Institute, almost exactly duplicates the description of P. *oxalicum* given above.

* Currie, J. M. and Thom, C., Jour. Biol. Chem. 22: 289, fig. 1. 1915.

** Thom, C., Op. cit., pp. 247–248, fig. 31. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., Op. cit., pp. 378–381. 1949.

P. atramentosum Thom.

FAT 1284.

The colony characteristics and microscopic characters are shown in Tables C–12 and M–12, respectively.

This strain is assigned to *P. atramentosum* Thom (1910, 1930*; Raper, Thom and Fennell, 1949**) because of the rather rapidly spreading growth, the typically velvety colonies, the production of orange pink shades, becoming reddish, in the reverse, the biverticillate and asymmetrical penicilli, the smooth-walled or nearly so conidiophores, the more or less divergent arrangement of metulae, sterigmata of the acute type and loosely parallel arrangement, and elliptical conidia with walls smooth or nearly so.

However, it differs from *P. atramentosum* Thom (given above) in the typical yellow green color of its colonies.

Strain FAT 1284 was received in 1952 from Prof. K. Sakagachi, University of Tokyo, (NRRL 785) as *P. atramentosum* Thom, originally from

Drs. K. B. Raper and D. I. Fennell, University of Wisconsin.

* Thom, C., U. S. Dept. Agr., Bur. Anim. Ind., Bull. 118, pp. 65–66, fig. 24. 1910; The Penicillia, pp. 251–252. 1930.

** Raper, K. B., Thom, C. and Fennell, D. I., Op. cit., pp. 381–383. 1949.

P. digitatum Saccardo.

FAT 1331.

The colony characteristics and microscopic characters are shown in Tables C–12 and M–12, respectively.

The strain is assigned to *P. digitatum* Saccardo (1886*; Thom, 1910,** 1930; Raper, Thom and Fennell,*** 1949) because of the rather restsictedly and sparsely spreading colonies on Czapek agar, the luxriant and broadly spreading colonies on steep agar, the velutinous and plane colonies, the dull yellow green color of conidial area, the colorless reverse, becoming pale olive color, the biverticillate and asymmetrical penicilli with walls smooth or nearly so, the conidiophores with smooth or nearly so, the more or less divergent metulae, the rather long and variable sterigmata, and the cylindrical to elliptical conidia with walls smooth or nearly so.

Strain FAT 1331 was received in 1955 from Tokai-Kinki National Agricultural Experimental Station (their No. Ci–8) as *P. digitatum*.

* Saccardo, D., Mycotheca Italica as No. 986, Herbarium U. S. Dept. Agr.; Sylloge Funogrum, Vol. IV: 78, 1886.

** Thom, C., U. S. Dept. Agr. Bur. Anim. Ind., Bull. 118, pp. 31–33, fig. 3. 1910; and The Penicillia, pp. 242–245, fig. 29 and 30. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., Op. cit., pp. 386–390. 1949.

P. digitatum Saccardo var. *latum* Abe.*

FAT 605.

The colony characteristics and microscopic characters are shown in Tables C–12 and M–12, respectively.

Colonies on Czapek agar grow broadly spreading, attaining a diameter of 65 mm. in 10 to 12 days at 25°C; generally plane or smooth; with 1.2 mm. margin, abundantly sporulating in blue green shades, near Greenish Glaucous blue, and with typical dark blue green shades, near Dark Green, in the central area, becoming Sage Green with age; exudate lacking; odor pronounced, strongly aromatic near citrus fruit fragrance; reverse in dull yellow shades, with surrounding agar colorless; conidiophores arising primarily from the substratum or from basal felt, variable in length, commonly up to 60 to 320 μ in length by 4.0 to 5.0 μ in diameter, with apices enlarged to 4.3 to 6.3 μ in diameter, with walls smooth or nearly so; penicilli biverticillate and asymmetrical, commonly showing one or more branches in addition to the main axis, terminating in veticils of 2 to 4 metulae-bearing sterigmata; branches variable, commonly 12.0 to 18.7 μ in length by 3.1 to 5.3 μ in diameter; metulae usually variable in length, mostly 12.0 to 2.0 μ by 3.1 to 5.6 μ, compact or somewhat divergent; sterigmata in somewhat divergent verticils of 2 to 5, equally variable and ranging from 10.6 to

18.0 μ by 3.1 to 4.7 μ; conidia cylindrical to long elliptical, mostly 3.7 to 5.6 μ by 2.5 to 3.7 μ, and occasionally up to 6.2 to 7.5 μ by 2.5 to 4.4 μ, with smooth walls or nearly so; conidial chains loosely divergent or tangled, up to 60 to 120 μ in length; conidia showing delicately roughened walls in electron microscopy (spins less than 0.1 μ). A colony's photograph and an electron micrograph are shown in Figs. C–18 and E–30, respectively.

Colonies on steep agar grow broadly, 78 mm. in 10 to 12 days at 25°C, with a somewhat broad white margin, 2.0 to 4.0 mm. wide, reverse in brownish shades; the other characters are as described above.

This strain differs from *P. digitatum* Saccardo** (1886; Thom, 1910; 1930; Raper, Thom and Fennell, 1949) primarily in the broadly spreading and luxuriantly growing colonies on Czapek agar, the typical blue-green color of its colonies, and also in the length of its conidiophores (60 to 320 μ).

Careful consideration of all described species and varieties of *Penicillium* has faild to reveal one which adequately characterizes the above strain.

The author, therefore, consider the strain as representing a new variety to which the name *P. digitatum* Saccardo var. latum Abe is assigned.

The verietal name is taken from the Latin, *latum* (meaning broad), and is applied because of the broadly spreading character of its colonies.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). May, 1953.
** See, *P. digitatum* Saccardo.

P. roqueforti Thom.

FAT 731, 733, 1136, 1000, 1257, 1260, 1258, 1253, 42, 543, 1271.

The colony characteristics and microscopic characters are shown in Tables C–13 and M–12, respectively.

The strains are assigned to *P. roqueforti* Thom (1906, 1910, 1930*; Raper, Thom and Fennell, 1949**) because of the rather rapidly or broadly spreading character of growth, typical velevety or velutinous colonies, the typical yellow green or dull yellow green color of the conidial areas, the colorless, green, or pinkish and fuscous pigmentation in the reverse, the colorless surrounding agar, the typically asymmetrical and biverticillate penicilli, the protuberculate or granular (0.6 to 1.0 μ) walls of conidiophores and branches, the loosely compact or somewhat divergent arrangement of metulae, the sterigmata of the acute type and loosely compact arrangement, the typically globose conidia with walls smooth or nearly so, and also the loosely columnar or tangled conidial chains.

These strains are clearly separable into five types, as shown Tables C–13 and M–12, judging by colony color, pigments developed in the colony reverse, character of the margin, and length of the conidiophores.

Strain FAT 731 and FAT 733 were isolated from roqueforti cheese; FAT 1253, 1257, 1260, 1258 was received in 1951 from Prof. G. Yoneyama, University of Hiroshima, (their Nos. 2 B, Ark, 12 a, Ark ?) isolated from a „Toyama Ganyaku" as an unknown *Penicillium*; and FAT 42 was received

in 1949 from Prof. K. Sakaguchi, University of Tokyo, as a *Penicillium* (their No. W. G. F.-2), isolated from a grape wine.

However, these strains differ somewhat from *P. roqueforti* Thom (descriptions cited above) in the typical yellow green colony color in some strains, in the usually colorless or sometimes pinkish shades in reverse, in the production of an arachnoid margin in some strains, and the long (380 to 700 μ) conidiophores in some strains. Another culture, FAT 1379 was received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, as *P. asperulum* Bainier, (their No. 6003); FAT 1321 was received in 1955 from Mr. I. Kanai, Department Central Research Institute, Japan Monopoly Corperation Tobacco Research, as their No. 12; FAT 1464 was received in 1955 from Mr. T. Hasegawa, Institute of Fermentation, Osaka, (their No. 4622), as *P. roqueforti* Thom; and FAT 1477 was recived in 1955 from Microbiological Laboratory, University of Kyoto, (their No. P. 1129), *P. roqueforti* Thom; these duplicated almost exactly the description of *P. roqueforti* as given above.

* Thom, C., U. S. Dept. Agr. Bur. Anim. Ind., Bull. 82, pp. 35-36, fig. 2. 1906; also Ibid., 118, p. 34, fig. 4. 1910; The Penicillia, pp. 277-279, fig. 38. 1930.

** Raper, K. B., Thom, C. and Fennell, D. I., Op. cit. pp. 395-401, 1949.

P. roqueforti Thom var. *punctatum* Abe.*

FAT 314, 315.

The colony characteristics and microscopic characters are shown in Tables C-13 and M-12, respectively.

Colonies on Czapek agar grow rather broadly, attaining a diameter of 58 to 62 mm. in 10 to 12 days at 25°C; comparatively heavy sporulating; velutinous, with surface fairly smooth or slightly radially furrowed in marginal areas, with a white margin about 1.2 mm. wide; conidial areas in yellow green shades, near Deep Dull Yellow Green becoming Citrine Drab with age; exudate abundant, colorless; odor not characteristic or pronounced, slightly sour or moldy; reverse colorless becoming pale pink, near Avellaneous throughout, with surrounding agar colorless; conidiophores arising primarily from the substratum or from basal felt, varibale in length, commonly up to 120 to 380 μ in length by 4.3 to 5.3 in diameter, with apices 4.3 to 5.6 μ long, with walls typically punctate or small granular; penicilli biverticillate and asymmetrical, commonly showing one or more branches in addition to the main axis, terminating in verticils of 2 to 5 metulae-bearing sterigmata; branches variable, commonly 12.5 to 31.0 μ in length by 3.1 to 4.7 μ in diameter, with punctate or small granular walls; metulae usually 12.5 to 18.7 μ by 3.1 to 4.5 μ, loosely compact or somewhat divergent, with smooth or punctate walls; sterigmata in loosely compact vreticils of 3 to 6, mostly 10.6 to 14.3 μ by 2.5 to 3.6 μ, acute type; conidia globose to subglobose, mostly 2.5 to 4.3 μ, delicately echinulate or ver-

ruculose walls; conidial chains usually tangled or somewhat divergent, up to 60 to 190 μ in length; conidial walls delicately echinulate or verruculose as seen in electron microscpy.

A colony's photograph and electron micrographs are shown in Figs. C–19 and M–31, 32, respectively.

Colonies on steep agar grow rather broadly, 58 to 67 mm. in 10 to 12 days at 25°C; velutinous, with surface typically furrowed; conidial areas in bright yellow green shades becoming yellowish olive; reverse brownish shades; the other characters are as described above.

These strains differ from *P. roqueforti* Thom** (1906, 1910, 1930; Raper, Thom and Fennell, 1949) primarily in the delicately echinulate or verruculese walls of the conidia, in the punctate or small granular walls of conidiophores and branches and metulae, in the pigmentation of the reverse, and also in not producing an arachnoid margin. Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characterizes the above strains.

The author, therefore, considers them as representing a new variety to which the name *P. roqueforti* Thom var. *punctatum* Abe is assigned.

The strains were isolated in 1949 from a cheese made in Japan.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). May, 1953.

** See, *P. roqueforti* Thom.

P. casei Staub.

FAT 817, 1046, 1030, 915.

The colony characteristics and microscopic characters are shown in Tables C–13 and M–12, respectively.

The strains are assigned to *P. casei* Staub (1911*; Thom, 1930**; Raper, Thom and Fennell,*** 1949) because of the typical velvety or velutinous, radially furrowed colonies, the bright yellow or dull yellow green conidial areas, the yellow, orange or brown shades in reverse, the pinkish or orange shades of the surrounding agar, the typical biverticillate and asymmetrical penicilli, the conidiophore walls with typical protuberances or large granules, the loosely compact arrangement and the punctate or granular walls of the metulae, the loosely compact arrangement of the acute type sterigmata with walls smooth or nearly so, the typical elliptical to subglobose conidia walls smooth or nearly so and the loosely columnar or tangled conidial chains. The strains are clearly separable into two types, as shown in Tables C–13 and M–12, on the basis of rate of growth, and colony circumference.

These strains differ more or less from the above descriptions of *P. casei* Staub (given above) in the rather rapidly or broadly spreading character of growth, in the elliptical to subglobose rather than subglobose to broadly elliptical, conidia, and in the production of a milky pigment in the reverse of some strains.

However, since they cannot be satisfactorily assigned to any other

described species. The author have assigned these to *P. casei* Staub because of the similarities described above. The author must here question the classification made by Thom** (1930) and Raper, Thom and Fennell*** (1949).

* Staub, W., Centbl. f. Bakt. etc. (II) 31: 454-466, 1911.

** Thom, C., Op. cit., p. 270. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., Op. cit., pp. 401-402, 1949.

P. casei Staub var. *compactum* Abe*

FAT 1276.

The colony characteristics and microscopic characters are shown in Tables C–13 and M–12, respectively. A colony's photograph and an electron micrograph are shown in Figs. C–20 and E–33, respectively.

Colonies on Czapek agar are rather restrictedly spreading, attaining a diameter of about 34 mm. in 10 to 12 days at 25°C, cansisiting of a comparatively hard basal felt bearing crowed conidial structures, with a white narrow margin, about 0.3 mm. wide, typically radially furrowed; conidial areas in yellow green shades near Dark Yellowish Green, becoming Andover Green with age; exudate abundant, in yellow or pinkish shades; odor lacking or limited, moldy; conidiophores arising from the substratum or from the basal felt, variable in length, commonly up to 60 to 300 μ by 4.4 to 6.2 μ in diameter, with walls showing large granules or protuberances; penicilli biverticillate and asymmetrical and comparatively compact, commonly showing one or more branches in addition to the main axis, terminating in verticles of 2 to 3 metulae-bearing sterigmata; branches variable, commonly 9.3 to 15.6 μ by 4.4 to 6.0 μ; metulae usually 6.2 to 11.2 μ by 2.5 to 4.3 μ, with apices 3.7 to 5.0 μ in diameter, with granular walls; sterigmata in fairly compact verticils of 3 to 6, mostly 8.7 to 10.6 μ by 2.5 to 3.2 μ, acute type with smooth or slightly punctate walls; conidia ovate to subglobose, mostly 3.1 to 4.3 by 3.0 to 3.8 μ, spinulose walls; conidial chains usually columnar or loosely columnar, up to 60 to 150 μ in length; and conidia with typical spinulose walls, shown in Fig. E–33 as seen by electron microscopy. Colonies on steep agar are similar to those described above.

This strain differs markedly from *P. casei* Staub** primarily in the spinulose walls of its conidia, in the milky color in the reverse, in the brevi-compactum-like structure of its penicilli, and in seldom growing at 37°C.

It also differs markedly from *P. brevi-compactum**** Dierckx, primarily in the typical conspicuously rough walls of its conidiophores and branches.

However, since the strain cannot be satifactorily assigned to any other described species or variety of *Penicillium*, the author considers it to represent a new variety to which the name *P. casei* Staub var. *compactum* Abe is assigned.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo), May, 1953.

** See, *P. casei* Staub.

*** See, *P. brevi-compactum* Dierckx.

P. pseudo-casei Abe.*

FAT 317, 1166.

The colony characteristics and microscopic characters are shown in Tables C–13 and M–12, respectively. A colony's photograph and an electron micrograph are shown in Figs. C–21 and M–34, respectively.

Colonies on Czapek agar grow rather rapidly, attaining a diameter of 53 to 55 mm. in 10 to 12 days at 25°C, consisting of a comparatively hard basal felt bearing crowded conidial structures; typically velvety, with a white margin 0.5 to 1.2 mm. wide; strongly furrowed in a radial pattern; conidial areas in bright yellow green shades near Winter Green, becoming Dark Yellowish Green or Light Drab; exudate limited, colorless; odor limited, moldy; reverse in colorless or pale yellow shades; with surrounding agar colorless; conidiophores arising primarily from the substratum or from basal felt, variable in length, commonly up to 120 to 250 μ in length by 3.1 to 4.7 μ in diameter, with apices 3.7 to 5.6 μ in diameter, and walls showing protuberances or larger granules; penicilli biverticillate and asymmetrical, commonly showing one or more branches in addition to the main axis, terminating in verticils of 3 to 5 metulae-bearing sterigmata; branches variable, commonly 15.6 to 34.0 μ by 2.5 to 4.4 μ; metulae usually 10.6 to 13.6 μ by 2.5 to 4.1 μ, loosely compact, with apices 3.1 to 4.6 μ in diameter; sterigmata in fairly or loosely compact verticils of 3 to 6, mostly 10.6 to 13.1 μ by 1.8 to 3.0 μ, acute type; conidia typically elliptical to ovate, mostly 3.1 to 4.1 μ by 3.0 to 3.4 μ, with smooth walls or nearly so; conidial chains usually loosely columnar or tangled, up to 60 to 190 μ in length; conidia showing smooth or nearly so walls in electron microscopy.

Colonies on steep agar are rather broadly spreading, 60 to 64 mm. in 10 to 12 days at 25°C; the other characters are as described above.

These strains differ markedly from *P. casei*** Staub (described above) primarily in the typically elliptical conidia, the rather rapidly spreading growth, the colorless or pale yellow reverse, the colorless surrounding agar, the conidia 3.1 to 4.1 μ long, the sterigmata 10.6 to 13.6 μ in length, the luxuriantly growth on Sakaguchi and Wang agar, and the lack of an arachnoid margin.

Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characters the above strains.

The author, therefore, regards the cultures in question as representing a new species, to which the binomial *Penicillium pseudo-casei* Abe is applied.

The species name is taken from the Latin, *pseudo-casei* (meaning false-casei), and is applied because of the superficial resemblance *P. casei*.

The correct placement of the species remains in doubt, but it appears to be most satisfactorily assignable to a series with *P. casei* Staub in the Velutina subsection of the Asymmetrica as classified by Thom, and Raper, Thom and Fennell.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo), May, 1953.

** See, *P. casei Staub*.

P. brevi-compactum Dierckx.

FAT 1285.

The colony characteristics and microscopic characters are shown in Tables C–14 and M–13, respectively.

The strain is assighed to *P. brevi-compactum* Dierckx (1901*; Biourge,** 1923; Thom, 1930***; Raper, Thom and Fennell, 1949****) because of the restricted character of growth, the velvety and lightly wrinkled colonies, the dull yellow green color of its conidial areas, the pigmentation in dull or pale yellow colors in the reverse and surrounding agar, the biverticillate and asymmetrical penicilli, the delicately rough-walled conidiophores, the short and compact arrangement of its branches and metulae, the acute type of sterigmata with compact or more or less inflated arrangement, and the typically globose to subglobose conidia with walls smooth or nearly so.

However, the strain differs somewhat from the above descriptions in the size (2.1 to 3.4 μ) of its conidia, in the diameter (2.1 to 3.0 μ) of its sterigmata, in the length (5.0 to 9.4 μ) of its metulae, and in the restricted (about 29 mm. in 10 to 12 days at 25°C) character of its growth.

Strain FAT 1285, received is 1952 from Prof. K. Sakaguchi, University of Tokyo, was sent originally from Drs. K. B. Raper and D. I. Fennell, University of Wisconsin, (NRRL 2011) as *P. brevi-compactum* Dierckx.

* Dierckx, R. P., Soc. Scien. Brux. 25: 88. 1901.

** Biourge, PH., Monogr., La Cellule 33: fasc. 1, pp. 155–157; Col. Pl. II and Pl. III, fig. 16. 1923.

*** Thom, C., The Penicillia, pp. 295–296. 1930.

**** Raper, K. B., Thom, C. and Fennell, D. I., Op. cit., pp. 407–411. 1949.

P. stoloniferum Thom.

FAT 684, 815, 1202, 507, 90, 709.

The colony characteristics and microscopic characters are shown in Tables C–14 and M–13, respectively.

The strains are assigned to *P. stoloniferum* Thom (1910, 1930*; Raper, Thom and Fennell,** 1949) because of the typical velvety colony character, the yellow green color of conidial areas, the pigmentation in dull yellow or pale olive colors in the reverse, the colorless or pale yellow surrounding agar, the biverticillate and asymmetrical penicilli, the smooth, or slightly rough-walled and occasionally sinuous conidiophores, the short or longer branches having a compact arrangement, the parallel or slightly divergent arrangement of the metulae, the acute type of sterigmata in a compact arrangemnet, the parallel or slightly divergent arrangement of the metulae, the acute type of sterigmata in compact arrangement, and typically elliptical to subglobose conidia with walls echinulate or verruculose.

The strains are clearly separable into three types (shown in Tables C–14 and M–13) on the basis of circumference of colonies, production of stolons in the margin, pigments developed in the colony reverse, in the character of conidiophore walls, and in the size of conidia, sterigmata and metulae.

They differ somewhat from the descriptions cited above in the rather restricted or rapidly spreading growth (35 to 54 mm. in 10 to 12 days at 25°C on Czapek agar), and in not producing a "stolon-like" margin in strain FAT 709, the typical rough walls of the conidiophores in some strains (FAT 709, etc.), the delicately or typically echinulate or verruculose walls of the conidia, typically elliptical to subglobose conidia, and the size of conidia, sterigmata and metulae in strain FAT 709. Another culture, FAT 1319, was received in 1955 from Mr. I. Kanai, Department Central Research, Institute, Japan Monopoly Corporation Tobacco Research, their No. 13, and FAT 1466 was received in 1955 from Mr. T. Hasegawa, Institute of Fermentation, Osaka, (their No. 4633), as *P. patulum* Bainier; these duplicate almost exactly description of *P. stoloniferum* (FAT 684) as given above.

* Thom, C., U. S. Dept. Agr., Bur. Anim. Ind., Bull. 118, 68-69, fig. 26. 1910; The Penicillia, 292-294, figs. 41 and 42. 1930.

** Raper, K. B., Thom, C. and Fennell, D. I., Op. cit., pp. 412-414. 1949.

P. brunneo-stoloniferum Abe.*

FAT 1132.

The colony characteristics and microscopic characters are shown in Tables C–14 and M–13, respectively.

Colonies on Czapek agar rather rapidly, attaining a diameter of approximately 46 mm. in 10 to 12 days at 25°C; strongly wrinkled and buckled, with central area somewhat raised, consisting of a close-textured mycelial felt bearing abundant conidial structures, with surface typically velvety, with a white margin 1.0 mm. wide, and colony circumference slightly rugged; conidial structures abundantly produced throughout the whole colony, typically in light brown shades near Buckthorn Brown or Clay, becoming Verona Brown in marginal areas and Soyal Brown in central areas with age; exduate lacking; odor limited, moldy; reverse in yellow or light brown shakes near Antimony Yellow or Cinnamon, becoming Soyal Brown in central areas and Yellow Ocher in marginal areas; surrounding agar strongly diffused in yellow shades; conidiophores arising from the substratum or basel felt, ranging up to 120 to 220 μ in length by 4.1 to 5.0 μ in diameter, with apices 4.4 to 6.2 μ in diameter, and small punctate walls; penicilli typically biverticillate and asymmetrical, short and compact, commonly one or more branches in addition to the main axis, terminating in verticils of 3 to 6 metulae-bearing sterigmata; branches usually short, 17.5 to 18.7 μ in length by 3.1 to 4.3 μ in diameter; usually 9.3 to 12.5 μ by 3.1 to 3.7 μ; sterigmata in fairly compact verticils of 4 to 7, mostly 9.3 to 11.2 μ by 2.1 to 2.6 μ, acute type; conidia elliptical to subglobose, mostly 2.3 to 3.3 μ by 2.1 to 2.8 μ, echinulate or verruculose walls; conidial chains loosely parallel to divergent, up to 60 to 170 μ in length; and conidia showing echinulate or verruculose walls in electron microscopy. A colony's photograph and an electron micrograph are shown in Figs. C–22 and E–35, respectively.

Colonies on steep agar rapidly, about 44 mm. in 10 to 12 days at 25°C; the other characters are as described above.

This strain differs from *P. stoloniferum* Thom** primarily in the bright brown shades of its conidial areas, in the rather rapidly spreading character of its growth, the typically elliptical to subglobose form of its conidia, the raugh-walls of its conidiophores, and also in the non-production of a stolon-margin.

Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characterizes the above strain.

Therefore, author recognized this strain as representing a new species to which the binomial *P. brunneo-stoloniferum* Abe is assigned.

The specific name is taken from the Latin, *brunneo-stoloniferum* (meaning like-stoloniferum, and brown), and is applied because of the resemblance to the above species and the typical brown color of its conidial areas.

The strain was isolated in 1949 from soil in Japan by the author and Mr. Y. Nakano, University of Tokyo.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). May, 1953.
** See, *P. stoloniferum* Thom.
*** Raper, K. B., Thom, C. and Fennell, D. I., Op. cit., pp. 404-418. 1949.

Fasciculata Sub-section.

P. ochraceum Thom.

FBT 766.

The colony characteristics and microscopic characters are shown in Tables C–15 and M–14, respectively.

The strain is assigned to *P. ochraceum* Thom (1930*; Raper, Thom and Fennell,** 1949) because of the rather rapidly spreading growth, the velutinous or fasciculate colonies, the typical yellowish olive conidial areas, the vinaceous pigmentation in reverse, the biverticillate and asymmetrical penicilli, the typically rough-walled and fasciculate conidiophores, the punctate walled branches, the loosely compact arrangement of metulae, the loosely compact arrangement of its acute type sterigmata, and the globose to subglobose conidia with slightly spinulose walls.

However, this strain differs somewhat from the descriptions cited above, in the colorless or pale pink exudate, and the typical brown pigmentation in the reverse on steep agar.

* Thom, C., The Penicillia, pp. 309-310. 1930.
** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 477-479. 1949.

P. crustosum Thom.

FAT 703, 735, 1133, 352, 371, 584, 593, 589, 1058, 1025, 218, 847, 553, 1227, 143, 1303, 318, 705, 1018.

The colony characteristics and microscopic characters are shown in Tables C–15 and M–14, repectively.

The strains are assigned to *P. crustosum* Thom (1930*; Raper, Thom and Fennell, 1949**) because of the rapidly spreading growth, the typically fasciculate colonies, the bright yellow-green or yellow green, and in some strain bluish-yellow green, conidial areas, the colorless or lighter yellow reverse, the usually colorless surrounding agar, the biverticillate and asymmetrical penicilli, the typical conspicuously roughened walls of conidiophores and branches, the loosely compact arrangement of metulae, the loosely compact arrangement of sterigmata of the acute type, the typically globose to subglobose conidia with walls smooth or nearly so, the tangled or loosely parallel conidial chains and character of usually forming definite crusts of conidia which easily break away when the culture tube or dish is tapped.

These are clearly separable into four types as shown in Tables C–15 and M–14, on the basis of colony colors, length of conidiophores, size of conidia and depth of colonies, but all strains usually produced definite crusts of conidia.

However, the strains differ more or less from the descriptions cited above in the bright yellow green colony color in some strains and the bluish-yellow green colors in others, in the slowly developing weak yellow or brownish pigmentation of the reverse, and in the usually globose to subglobose conidia.

* Thom, C., The Pencillia, p. 399. 1930.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 516-518. 1949.

P. viridicatum Westling.

FAT 818, 851, 999, 1273.

The colony characteristics and microscopic characters are shown in Tables C–15 and M –14, respectively.

The strains are assigned to *P. viridicatum* Westling (1911*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the typically fasciculate colonies, the typical bright yellow green color of conidial areas, usually remaing persistently green (during about 4 weeks), the yellow or orange to orange-brown colors of the reverse, the broadly pinkish, light brown or yellow shades of the surrounding agar, the biverticillate asymmetrical and enlarged penicilli, the typically granular walls of the conidiophores, the granular walls and loosely compact arrangement of metulae and branches, the acute type of sterigmata in loosely compact arrangement, and the globose to subglobose conidia with walls smooth or nearly so.

However, the strains differ somewhat from the descriptions cited above in the rather rapidly spreading growth, and in the strong pigmentation of the surrounding agar and reverse.

These strains are clearly separable into two types as shown in Tables C–15 and M–14, and the basis of size of conidia and penicilli.

* Westling, R., Arkiv. for Botanik 11: 53, 88-90, figs. 14 and 56. 1911.

** Thom, C., The Penicillia, p. 394. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Mannual of the Penicilia, pp. 482-487. 1949.

P. viridi-cyclopium Abe.*

FAT 843, 1044, 321, 842, 998, 841, 1043, 1042, 1224, 263.

The colony characteristics and microscopic characters are shown in Tables C–15 and M–14, respectively. A colony's photograph and an electron micrograph are shown in Figs. C–23 and E–36, respectively.

Colonies on Czapek agar grow rather rapidly, attaining a diameter 30 to 47 mm. in 10 to 12 days at 25°C, with surface smooth or in some strains loosely furrowed; with a white margin 0.8 to 1.5 mm. wide; typically or slightly fasciculate, abundantly sporulating throughout in most strains; conidial areas in typical yellow-green or bluish yellow green colors, in some strains, typical blue green; with surrounding agar usually quickly developing cinnamon or pinkish cinnamon shades, becoming orange cinnamon or brownish, broadly; exudate limited, colorless or pale yellow; odor abundant, moldy; conidiophores primarily arising from the substratum, commonly up to 120 to 380 or 440 μ in length by 3.7 to 5.6 μ in diameter, apices 4.0 to 5.8 μ in diameter, with typical granular walls; penicilli biverticillate and asymmetrical, commonly showing one or more branches in addition to the main axis, terminating in verticils of 2 to 5 metulae-bearing sterigmata; branches variable, commonly 9.3 to 31.0 μ or 37.0 μ in length by 3.0 to 4.9 μ in diameter, with granular walls; metulae usually 7.5 to 15.6 μ by 2.5 to 4.5 μ, with smooth walls or nearly so; sterigmata in fairly compact or loosely compact verticils of 3 to 7, mostly 8.1 to 12.5 μ by 2.1 to 3.1 μ, acute type; conidia globose to subglobose, mostly 2.5 to 3.8 μ, smooth walled or nearly so; conidial chains loosely parallel or tangled, up to 50 to 220 or 260 μ in length.

Colonies on steep agar rather rapidly, 29 to 60 mm. in 10 to 12 days at 25°C, with surface usually radially furrowed; the other characters are as described above.

These strains are separable into three types (as shown in Tables C–15 and M–14) on the basis of typical colors of conidial areas.

Following the classification by Raper, Thom and Fennell** (1949), the first type, (FAT 843, 1044, 321, 842 and 998) is suggestive of *P. olivino-viride**** or *P. palitans***** because of the yellow green conidial celors; the second type, (FAT 1042, 1224 and 263.) is suggestive of *P. cyclopium* or *puberulum* because of the blue-green conidial color; and the third type, (FAT 841 and 1043) is suggestive of *P. cyclopium* Westling and the *P. viridicatum* series because of the typical bluish-yellow green conidial colors.

However, all the strains duplicated almost exactly all the characters except color of conidial areas described above.

They differ markedly from *P. puberulum* Bainier, *P. martensii* Biourge and *P. aurantio-virens* Biourge primarily in the globose form of the conidia

and the typically strongly pigmented surrounding agar in brownish colors.

They also differ somewhat from *P. viridicatum* Westling primarily in the colors of conidial areas as described above, from *P. olivino-viride* Biourge in fact that color of conidial areas changes only slowly, and in the smooth or nearly so conidial walls, and from *P. palitans* Westling in the colors of conidial areas as described above.

For some reason the pigmentation the surrounding agar of the *P. viridicatum* series and *P. cyclopium* Westling is not described in Thom, (1930) and Raper, Thom and Fennell's (1949) classification.

The author have found no pigmention surrounding the colonies on Czapek and Steep agar in *P. viridicatum*, *P. olivino-viride*, *P. palitans*, and *P. cyclopium*.

Accordingly, since they cannot be satisfactorily assigned to any other described species or varieties, the author consider these strains a new species to which the binomial *P. viridi-cyclopium* Abe is assigned.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Sapporo). Aug., 1953.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, 1949. Thom, C., The Penicillia. 1930.

*** See, each species.

P. olivino-viride Biourge.

FAT 704, 634, 636, 1009, 373, 997, 983, 633, 572.

The colony characteristics and microscopic characters are shown in Tables C–15 and M–14, respectively.

The strains are assigned to *P. olivino-viride* Biourge (1923*; Thom, 1930**; Raper, Thom and Fennell***, 1949) because of the typically fasciculate or slightly fasciculate colonies, the bright or dull yellow green, quickly becoming olive or grayish, conidial areas, the light or pale yellow, becoming light brown or pale pink, in the reverse, the biverticillate, asymmetrical and comparatively larger penicilli, the typically granular walls of the conidiophores, the loosely compact arrangement of metulae and branches, the acute type sterigmata with loosely compact arrangement and the typically globose to subglobose conidia.

These are clearly separable into three types, as shown in Tables C–15 and M–14, on the basis of colors of colonies, pigmentation of the reverse and surrounding agar, and the characters of the colony surface.

However, the strains differ somewhat from the descriptions cited above in the rather rapidly spreading growth, and the conidia with walls smooth or nearly so.

Some other cultures, FAT 1323 received in 1955 from Mr. I. Kanai, Department Central Research Institute, Japan Monopoly Corporation Tobacco Research, (their No. 11); FAT 1453 received in 1955 from Yamasaki Laboratory, University of Kyushu, as *P. granulatum* Bainier; FAT 1350 and

1349, received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, their Nos. 6006 and 6005) as *P. chlorophaeum* Biourge var., duplicated almost exactly the description of *P. olivino-viride* as presented above.

* Biourge, Ph., Monograph, La Cellule 33: fasc. 1, pp. 132–133, Col. Pl. II and Pl. II, fig. 12. 1923.

** Thom, C., The Penicillia, pp. 393–394. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 487–488. 1949.

P. palitans Westling.

FAT 985, 838.

The colony characteristics and microscopic characters are shown in Tables C–15 and M–14, respectively.

The strains are assigned to *P. palitans* Westling (1911*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the rather rapidly spreading growth, the slightly fasciculate colonies, the darker yellow green conidial areas, the colorless or pale yellow reverse, the typically granular walls of conidiophores and branches; the loosely compact arrangement of metulae, with punctate or slightly granular walls, the acute type of sterigmata in a loosely compact arrangement, the globose to subglobose conidia with walls smooth or nearly so, and the tangled, loosely parallel or divergent conidial chains

However, the strains differ somewhat from the descriptions cited above in the near Andover Green shades of the conidial areas, and in the rate of growth (42 to 50 mm. in 10 to 12 days at 25°C).

* Westling, R., Arkiv. for Botanik 11: 53, 83–86, figs. 12 and 54. 1911.

** Thom, C., The Penicillia, pp. 396–397. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 488–489. 1949.

P. puberulum Bainier.

FAT 1304, 1262.

The colony characteristics and microscopic characters are shown in Tables C–15 and M–14, respectively.

The strains are assigned to *P. puberulum* Bainier (1907*; Alsberg and Black, 1913**; Thom, 1930***; Raper, Thom and Fennell, 1949****) because of the slightly fasciculate colonies, the typical blue-green color of conidial areas, quickly changing to darker or grayish green, the dull, weakly yellow reverse, changing to cinnamon or pinkish cinnamon, the colorless surrounding agar, the biverticillate and asymmetrical penicilli, the granular conidiophore walls, the loosely compact arrangement of branches and metulae, the acute type sterigmata in loosely compact arrangement, the globose to subglobose conidia with smooth walls or nearly so.

However, the strains differ somewhat from the descriptions cited above in the rather rapidly spreading growth, the sterigmata 10.0 to 11.3 μ or

12.5 μ in length, and the conidiophore walls typically granular rather than more or less roughened.

* Bainier, G., Bul. Soc. Mycol. France 23: 16-17; Pl. IV, figs. 6-12. 1907.
** Alsberb, C. L. and Black, O. F., U. S. D. A., Bur. Plant Ind. Bull. 270; pp. 12-33. 1913.
*** Thom, C., The Penicillia, pp. 271-272, figs. 36 and 37. 1930.
**** Raper, K. B., Thom, C., and Fennell, D. I., A Manual of the Penicillia, pp. 497-500. 1949.

P. cyclopium Westling.

FAT 1052, 1053, 1310, 642, 840, 845.

The colony characteristics and microscopic characters are shown in Tables C-15 and M-14, respectively.

The strains are assigned to *P. cyclopium* Westling (1911*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the rather rapidly spreading growth, the typically fasciculate colonies, the typically blue-green conidial areas, the colorless, light drab or smoke gray reverse, the colorless surrounding agar, the biverticillate and asymmetrical penicilli, the typically granular walled conidiophores, and the loosely compact arrangement of branches and metulae, the acute type sterigmata in loosely compact arrangement, the typically elliptical to subglobose conidia with walls smooth or nearly so.

However, the strains differ somewhat from the descriptions cited above in the typically elliptical conidia, abundantly produced.

* Westling, R., Arkiv. for Botanik 11: 55-56, 90-92, figs. 15, 57. 1911.
** Thom, C., The Penicillia, pp. 384-385. 1930.
*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicilia, pp. 493-497. 1949.

P. aurantio-virens Biourge.

FAT 1226, 1225, 1118, 334, 836, 1297.

The colony characteristics and microscopic characters are shown in Tables C-15 and M-14, respectively.

The strains are assigned to *P. aurantio-virens* Biourge (1923*: Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the somewhat rapidly spreading growth, the typically fasciculate colonies, the blue-green conidial areas, the dull yellow color becoming brownish in the reverse, the dull yellow surrounding agar, the biverticillate and asymmetrical penicilli, the typically granular walled conidiophores, the loosely compact arrangement of branches or metulae, the acute type of sterigmata in loosely compact arrangement, the typically elliptical to ovate conidia with walls smooth or nearly so, and also on malt agar the characteristics of restricted spreading, tard light sporulating and numerous irregular sterile areas.

However, these strains differ from the descriptions cited above in the sterigmata mostly 9.3 to 12.5 μ in length, and in the pigmentation of the

reverse and surrounding agar weaker then reported.

Conidial areas dark yellow green: FAT 887.

This strain duplicates the species in rate of growth, texture, colors in the reverse, exudate, and surrounding agar, penicilli, conidiophores, conidia, and characters on malt agar; the conidial areas are typically dark yellow green (as shown in Tables C–15 and M–14). It differs markedly from *P. olivino-viride* and *P. palitans* in the typical from of its conidia. Therefore, the author believes it most satisfactory to assign this strain to *P. aurantio-virens*, in spite of these differences.

* Biourge, Ph., Monograph, La Cellule 33: fasc. 1. pp. 119–121. 1923.

** Thom, C., The Penicillia, pp. 316–317. 1913.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 403–505. 1949.

P. palitans Westling var. *echinoconidium* Abe.*

FAT 848, 1019.

The colony characteristics and microscopic characters are shown in Tables C–15 and M–14, respectively.

Colonies on Czapek agar rather rapidly, spreading, attaining a diameter of 50 to 53 mm. in 10 to 12 days at 25°C, usually radially furrowed, and with surface appearing granular to definitely tufted, typically fasciculate, heavily sporulating throughout, with a white margin about 1.5 mm. wide; conidial areas in dark yellow green shades, near Dusky Yellow Green, becoming dark olive near Dusky Olive Green with agae; exudate limited, colorless; odor, definitely moldy; reverse colorless or pale yellow, becoming pale brown, with surrounding agar usually colorless, becoming tardily pale yellow; conidiophores usually arising directly from the substratum, commonly up to 120 to 320 μ in length by 4.3 to 6.0 μ in diameter, with tyipcal granular walls, penicilli generally showing 1 or 2 branches in addition to the main axis, branches typically appeard and often unequal in the same penicillus, commonly ranging from 11.2 to 24.0 μ by 3.4 to 5.0 μ; bearing metulae in groups of 3 to 5, mostly 9.3 to 13.7 μ or occasionally 18.7 μ by 2.8 to 4.7 μ; sterigmata usually borne in loosely compact verticils of 4 to 8, mostly 10.0 to 11.9 μ by 2.5 to 3.1 μ, acute type; conidia globose to subglobose, mostly 3.1 to 4.3 μ, with walls conspicuously echinulate or verruculose, conidial chains variable, tangled, loosely parallel or divergent, up to 60 to 120 μ in length; conidia walls typically conspicously echinulate or verruculose as shown in electron microscopy.

A colony's photograph and an electron micrograph are shown in Figs. C–24 and E–37, respectively.

Colonies on steep agar spread rather rapidly, 51 to 55 mm. in 10 to 12 days at 25°C; the other characters are as described above.

The strains differ from *P. palitans* Westling (1911**; Thom, 1930; Raper, Thom and Fennell, 1949) and *P. cyclopium* Westling var. *echinulatum* Raper,

Thom and Fennell, 1949*** primarily in the typical conspicuously echinulate or verruculose walls of the conidia and usually producing the typical dark yellow green shades, near Dusky Yellowish Green (markedly different from the near Sage Green of NRRL 1153).

Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characterizes the above strains.

The author, therefore, considers the cultures in question as representing a new variety, to which the name *P. palitans* Westling var. *echinoconidium* Abe is applied. Since *P. cyclopium* Westling var. *echinulatum* Raper, Thom and Fennell*** (1949) usually produced elliptical conidia, the author considers it most satisfactory to call it synonymous with *P. palitans* Westling var. *echinoconidum* Abe because of the globose to subglobose conidia with conspicuously echinulate or verruculose walls.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). Aug. 1953.

** See, *P. palitans* Westling.

*** See, *P. cyclopium* Westling var. *echinulatum* Raper, Thom and Fennell.

P. cyclopium Westling var. *echinulatum* Raper, Thom and Fennell.

FAT 987.

The colony characteristics and microscopic characters are shown in Tables C–15 and M–14, respectively. An electron micrograph is shown in Fig. E–38.

The strain is assigned to *P. cyclopium* Westling var. *echinulatum* Raper, Thom and Fennell*, (1949) because of the rather rapidly spreading growth, the typically fasciculate colonies, the typical dark blue-green color of conidial areas, the dull yellow or purple drab reverse, the colorless surrounding agar, the typically biverticillate and asymmetrical penicilli, the granular conidiophore walls, the loosely compact arrangement of branches and metulae, the acute type sterigmata in loosely compact arrangement, the globose to subglobose conidia with conspicuously echinulate or verruculose walls.

* Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, p. 497. 1949.

P. urticae Bainier.

FAT 1314, 1315.

The colony characteristics and microscopic characters are shown in Tables C–15 and M–14, respectively.

The strains are assigned to *P. urticae* Bainier (1907*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the restricted growth, the typically fasciculate colonies, the darker green shades, near Pea Green or Sage Green, of conidial areas, the dull yellow or orange cinnamon reverse, the pale cinnamon color of the surrounding agar, the biverticillate and asym-

metrical penicilli, the smooth or nearly so walls of conidiophores and branches, the loosely compact arrangement of metulae, the short and acute type of sterigmata, and the typically elliptical conidia with walls smooth or nearly so.

However, these strains differ somewhat from the descriptions cited above in the diameter of growth (30 to 32 mm.) and in the length of sterigmata (5.3 to 6.3 μ).

FAT 1314 was received in 1953 from Mr. G. Urakubo, Government Experimental Station for Hygiene, Tokyo, as Penicillum sp., isolated from deseased rice.

* Bainier, G., Bul. Soc. Mycol. France 23: Pl. V, figs. 10-16. 1907.

** Thom, C., The Penicillia, pp. 418-419, 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 534-537. 1949.

P. expansum (Link) Thom.

FAT 736, 740.

The colony characteristics and microscopic characters are shown in Tables C-15 and M-14, respectively.

The strains are assigned to *P. expansum* (Link) Thom (Thom, 1910, 1930*; Link, 1809**; Raper, Thom and Fennell, 1949***) because of the rapidly spreading growth, the typically fasciculate colonies, the dull yellow green conidial areas, the yellow-brown reverse, the pinkish or lightly yellow brown surrounding agar, the biverticillate and asymmetrical penicilli, the smooth or nearly so conidiophore walls, the loosely compact arrangement of branches or metulae, the acute type sterigmata in loosely compact arrangement, the typical strongly elliptical conidia with walls smooth or nearly so, and the conidia not forming a definite crust.

The strains differ somewhat from the descriptions cited above in the conidiophores usually 60 to 390 μ in length and in the conidia occasionally up to 5.6 to 6.5 μ by 3.4 to 4.1 μ.

Other cultures, FAT 1465, received in 1955 from Mr. T. Hasegawa, Institute for Fermentation, Osaka, (their No. 4676) as *P. claviforme* Bainier, and FAT 1327, received in 1955 from Prof. T. Nehira, Department Fermentation Technology, University of Hiroshima, as *P. expansum* (Koura) duplicated almost exactly the description of *P. expansum* as given above.

* Thom, C., U. S. Dept. Agr., Bur. Anim. Ind., Bul. 118, pp. 27-28, fig. 1. 1910.; The Penicillia, pp. 402-405, figs. 60 and 61. 1930.

** Link, H. F., Observationes. p. 17. 1809.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 512-516. 1949.

P. martensii Biourge.

FAT 305, 1201.

The colony characteristics and microscopic characters are shown in Tables C-15 and M-14, respectively.

The strains are assigned to *P. martensii* Biourge (1923*; Thom, 1930**; Raper, Thom and Fennell***, 1949) because of the somewhat restricted or rather rapidly spreading growth, the typically fasciculate colonies, the typical blue-green or bluish gray green conidial areas, the orange-brown or reddish brown, becoming blackish brown, reverse, the light brownish color, becoming dark brown, of the surrounding agar, the biverticillate and asymmetrical pencilli, the smooth walled or nearly so conidiophores, branches and metulae, the loosely compact arrangement of branches and metulae, the acute type sterigmata in compact or loosely compact arrangement, the typically elliptical or ovate conidia with walls smooth or nearly so; and the character of rapid growth on malt agar.

However, these differ somewhat from the descriptions cited above in the somewhat restrictedly spreading colonies and the typical blackisk brown reverse (FAT 305).

Another culture, FAT 1365, received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, (their No. 6037) as *P. martensii* Biourge, duplicated almost exactly the description of FAT 305 as given above.

* Biourge, PH., Monograph, La Cellule 33: fasc. 1, pp. 119-121; Col. Pl. I, fig, 5. 1923.

** Thom, C., The Penicillia, pp. 312-317. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 500-503. 1949.

P. italicum Wehmer.

FAT 744.

The colony characteristics and miscroscopic characters are shown in Tables C-15 and M-14, respectively.

The strain is assigned to *P. italicum* Wehmer (1895*; Thom, 1930;** Raper, Thom and Fennell, 1949***) because of the rather rapidly spreading growth, the typically fasciculate colonies, the bluish green shades of its conidial areas, the dull yellow reverse, the colorless surrounding agar, the biverticillate and asymmetrical penicilli, the smooth or nearly so walls of its conidiophores and branches, the loosely compact arrangement of its metulae, the loosely compact arrangement of sterigmata of the acute type, and the typically cylindrical to elliptical conidia with walls smooth or nearly so.

However, it differs somewhat from the descriptions cited above in the rather rapidly spreading growth, in the fact that conidia are not subglobose, and in the rather yellow green color of its central area.

Other cultures, FAT 1330 and FAT 1329, received in 1955, from Tea Division Pests and Blight, Tokai-Kinki National Agricultural Experimental Station, (their Nos. Pr-13 and Ci-9) as P. sp. and *P. italicum* Wehmer, duplicated almost exactly the description of *P. italicum* as given above.

* Wehmer, C., Beitz. Z. Kennth. Einh. Pilze, II, pp. 68-72; Taf. I. figs. 1-3, Taf. II, figs. 1-10, jena. 1895.

** Thom, C., The Penicillia, pp. 412–414, fig. 63. 1930.
*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 526–529. 1949.

P. corymbiferm Westling.

FAT 606.

The colony characteristics and microscopic characters are shown in Tables C–16 and M–15, respectively.

The strain is assigned to *P. corymbiferm* Westling (1911*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the rather rapid growth, the typically fasciculate and abundantly coremia form colonies, the yellow green color of its conidial areas, the yellow, becoming brownish, revere, the biverticillate and asymmetrical penicilli, the typically granular walls of conidiophores, branches and metulae, the loosely compact arrangement of metulae, the loosely compact sterigmata of the acute type, and the globose to subglobose conidia with walls smooth or nearly so.

However, it differs somewhat from the descriptions cited above in the sterigmata mostly 8.7 to 10.6 μ, rarely 12.0 μ, in length and in the near Deep Dull Yellow Green color of its conidial areas.

* Westling, G., Arkiv for Botanik 11: 56, 92–95; figs. 16, 58, 1911.
** Thom, C., The Penicillia, pp. 423–425, 1930.
*** Raper, K. B., Thom, C. and Fennell, D. I,, A Manual of the Penicillia, pp. 540–544. 1949.

P. granulatum Bainier.

FAT 852.

The colony characteristics and microscopic characters are shown in Tables C–16 and M–15, respectively.

The strain is assigned to *P. granulatum* Bainer (1905*; Thom, 1910**; Raper, Thom and Fennell, 1949***) because of the abundant coremia with colony surface appearing coarsely granular or ridged, the pale blue-green color of its conidial areas, the yellow to orange brown reverse, the dull brownish surrounding agar, the biverticillate and asymmetrical penicilli, the typically granular walls of its conidiophores and branches, the loosely compact arrangement and granular walls of its metulae, the acute type of sterigmata in loosely compact arrangement, the typically elliptical conidia with walls smooth or nearly so and the tangled or loosely divergent conidial chains.

However, the strain differs somewhat from the descriptions cited above in the rather rapidly spreading growth, in the sterigmata mostly 9.3 to 11.2 μ in length, and in the colony depth of 1.6 to 1.8 mm. on Czapek agar and 2.2 to 2.3 mm. on steep agar.

* Bainier, G., Bul. Soc. Mycol. France 21: 126–127; Pl. 11, figs. 5–7. 1905.
** Thom, C., U. S. Dept. Agr. Bur. Anim. Ind., Bul. 118, pp. 44–15, fig. 11. 1910; The Penicillia, pp. 429–430, fig. 66 and 67. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 544-547. 1949.

P. claviforme Bainier.

FAT 1162, 1263, 1266, 554, 135, 739.

The colony characteristics and microscopic characters are shown in Table C-16 and M-15, respectively.

The strains are assigned to *P. claviforme* Bainier (1905*; Thom, 1910**, 1930; Raper, Thom and Fennell, 1949***) because of the rather rapidly spreading growth, the prominently coremiform character of the colonies, the blue green or yellow green conidial areas, the orange or brownish reverse, the pale yellow or light brownish surrounding agar, the biverticillate and asymmetrical penicilli, the smooth or nearly so walls of conidiophores and branches, the loosely compact or somewhat divergent metulae with smooth walls, the acute type of sterigmata in loosely compact arrangement, the elliptical to ovate or subglobose conidia with walls smooth or nearly so, and the broadly columnar or parallel conidial chains.

However, they differ somewhat from the descriptions cited above in the rapidly or broadly spreading growth (57-68 mm. on Czapek agar), the usually deeply flocculent aerial mycelium abundant in the central area, the colonies 10 to 15 mm. wide, and the conidia mostly 2.8 to 3.8 μ by 2.5 to 3-1 μ.

Strains FAT 1263 and 1266 were received in 1952 from Mr. T. Ura, University of Kyoto, (their Nos. M-15 and M-3) as *Penicillium* sp.

* Bainier, O., Bul. Soc. Mycol. France 21: 127, Pl. XI, figs. 8-11. 1905.

** Thom, C., U. S. Dept. Agr., Bur. Anim. Ind., Bul. 118, p. 44, fig. 10. 1910; The Penicillia, pp. 432-433, fig. 68. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 549-553. 1949.

P. claviforme Bainier mut. *candicans* Abe and Ura.*

FAT 1277.

The colony characteristics and microscopic characters are shown in Tables C-16 and M-15, respectively.

Colonies of the variety *candicans* on Czapek and steep agar differ from the species in the entire absence of green color (Fig. C-25).

This strain, received in 1952 from Mr. T. Ura, University of Kyoto, (No. M 15-5) as *Penicillium* sp. was obtained from a normal green strain of FAT 1263 (described above) by ultra-violet irradiation. Therefore, we consider it as representing a new variety to which the name *P. claviforme* Bainier mut. *candicans* Abe and Ura is assigned because of the white color of its colonies.

* Abe, S., Paper read before the Agr. Chem. Soc., Japan (Tokyo), May, 1953.

P. claviforme Bainier mut. *olivicolor* Abe and Ura*.

FAT 1278.

The colony characteristics and microscopic characters are shown in Tables C–16 and M–15, respectively.

Colonies of the variety *olivicolor* on Czapek and steep agar differ from the species in the entire absence of green color (Fig. C–26).

The strain received in 1952 from Mr. T. Ura, University of Kyoto, (their No. M 15–9), as a *Penicillium* was obtained from a normal green strain of FAT 1263 (as described above) by ultra-violet irradiation. Therefore, we consider it as representing a new variety to which the name *P. claviforme* Bainier mut. *olivicolor* Abe and Ura is assigned because of the olivish color of its colonies.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). May, 1953.

P. clavigerum Demelius.

FAT 1161.

The colony characteristics and microscopic characters are shown in Table C–16 and M–15, respectively.

The strain is assigned to *P. clavigerume* Demelius (1923*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the somewhat restrictedly spreading growth, the very strongly fasciculate colony throughout, with the coremiform aspect dominating it, the coremia Isaria-like, the yellow green, becoming olive, conidial areas, the yellow shades, becoming pinkish brown, of the reverse, the colorless to pale yellow surrounding agar, the biverticillate and asymmetrical penicilli, the sinuous and variable in length conidiophores (2 to 10 mm.) with walls smooth or nearly so, the smooth walled and loosely compact or somewhat divergent metulae and branches, the sterigmata gradually tapered to conidium-bearing tips and loosely compact, the typically elliptical conidia with walls smooth or nearly so and conidia showing delicately roughened walls (less than 0.1 μ) in election microscopy.

A colony's photograph and an electron micrograph are shown in Figs. C–27 and M–39, respectively.

However, the strain differs somewhat from the descriptions cited above in the typically bright yellow shades, near Citron Yellow or Empire Yellow, in the lower part of the sterile areas of its coremia with apices gradually pointed (2 to 12 mm. in length) and in the sterigmata mostly 9.3 to 125 μ in length.

Another culture, FAT 1363 received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, (their No. 6011) as *P. claviforme* Bainier, duplicated almost exactly the description of *P. clavigerum* as given above.

* Demelius, P., Verhandl. Zool.-Bot. Gesellsch. Wein 72: 74–75, fig. 4. 1923.

** Thom, C., The Penicillia, p. 427. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 553–555. 1949.

Biverticillata-Symmetrica Section

P. wortmanni Klöcker.

FAT 364.

The colony characteristics and microscopic characters are shown in Tables C–17 and M–16, respectively.

The strain is assigned to *P. wortmanni* Klöcker (1903*; Biourge, 1923**; Thom, 1930, 1935***; Raper, Thom and Fennell, 1949***) because of the rather restricted growth, the slightly floccose or funiculose colonies, the bright yellow green conidial areas, the bright yellow mycelium, the pinkish orange reverse, the typically biverticillate and symmetrical penicilli, the comparatively short conidiophores with walls smooth or nearly so, the compact arrangement of its metulae, the closely parallel arrangement of lanceolate type sterigmata, the typically elliptical to lemon-shaped conidia with walls smooth or nearly so, the production of perithecia in Lemon Yellow or Apricot Yellow, elliptical (mostly 240 to 700 μ by 190 to 500 μ), and formed in 18 to 25 days, oval to sub-spherical asci (mostly 8 to 12 μ in diameter) with 8 spores, the colorless elliptical ascospores (mostly 3.4 to 5.6 μ by 2.8 to 37μ) with spinulose walls.

However, the strain differs somewhat from the description cited above in the size of perithecia, asci ascospores.

* Klöcker, A., Compt. Rend. Lab. Carlsberg 6: 100. 1903.

** Biourge, PH., Monograph. La Cellule 33: fasc. 1 pp. 243–244. 1923.

*** Thom, C., The Penicillia, pp. 449–450. 1930; Mycologia 27: 133–135, fig. 1. 1935.

**** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 583–586. 1949.

P. duclauxi Delacroix.

FAT 1293.

The colony characteristics and microscopic characters are shown in Tables C–17 and M–16, respectively.

The strain is assigned to *P. duclauxi* Delacroix (1891*; Thom, 1910, 1930**; Raper, Thom and Fennell, 1949***) because of the rather slowly spreading growth, the abundantly fasciculate colonies, mostly as true coremia 1 to 1.5 mm. high, the dark yellow green conidial areas, the reverse variously colored in yellow to orange-brown, becoming deep red, the yellow to light brown, becoming reddish, surrounding agar, the typically biverticillate and symmetrical penicilli, the smooth or nearly so conidiophore walls, the closely parallel metulae, the lanceolate sterigmata in closely parallel arrangement, and the elliptical or fusiform conidia with walls smooth or nearly so.

However, the strain differs from the descriptions cited above in the blackish yellow green, near Dull Blackish Green, conidial areas and the elliptical or fusiform conidia with walls smooth or nearly so.

Strain FAT 1293, received in 1952 from Prof. K. Sakaguchi, University of Tokyo, was originally sent from Drs. K. B. Raper and D. I. Fennell, University of Wisconsin, (their NRRL 2020) as *P. duclauxi* Delacroix.

* Delacroix, G., Bul. Soc. Myc. France 8: 107, Pl. VII. 1891.

** Thom, C., U. S. D. A., Bur. Anim. Ind., Bul. 118, p. 42, fig. 9. 1910; The Penicillia, pp. 458–459. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 610–613. 1949.

P. funiculosum Thom.

FAT 71, 1267.

The colony characteristics and microscopic characters are shown in Tables C–17 and M–16, respectively.

The strains are assigned to *P. funiculosum* Thom (1910, 1930*; Raper, Thom and Fennell, 1949**) because of the broadly spreading growth, the typically funiculose colonies, the yellow green conidial areas, the pale yellow, pink or white aerial mycelium, the deep red or purplish red, becoming dark brown-red, reverse, the colorless surrounding agar, the biverticillate and symmetrical penicilli, the smooth or nearly so conidiophore walls, the closely parallel arrangement of metulae, the lanceolate and closely parallel sterigmata, the fusiform or elliptical conidia with walls smooth or nearly so, and the loosely parallel or tangled conidial chains.

However, these strains differ markedly from the descriptions cited above in the blackish yellow green, near Dull Blackish Green becoming Dusky Olive Green, conidial areas, in the typically fusiform conidia, abundantly produced, and in the broad margin (5 mm. wide on Czapek agar and 15 mm. wide on steep agar).

Conidia show delicately roughened walls (less than 0.1 μ) in electron microscopy (Fig. E–40).

Strain FAT 1267 was received in 1952 from Mr. T. Hasegawa, Institute for Fermentation, Osaka, (their No. P–46) as *P. duclauxi* Delacroix.

* Thom, C., U. S. Dept. Agr., Bur. Anim. Ind., Bul. 118. p. 69, fig. 27. 1910; The Penicillia, pp. 464–465. fig. 77. 1930.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 616–621. 1949.

P. islandicum Sopp.

FAT 1212, 946, 1270, 777, 778, 355.

The colony characteristics and microscopic characters are shown in Tables C–17 and M–16, respectively. An electron micrograph is shown in Fig. E–41.

The strains are assigned to *P. islandicum* Sopp (1912*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the slow or restricted growth, the typically funiculose and zonate colonies, the abundant and orange or red-orange aerial mycelium, the orange brown or reddish reverse, the

orange, reddish or yellow surrounding agar, the typically biverticillate and symmetrical penicilli, the comparatively short conidiophores with walls smooth or nearly so, the loosely compact or somewhat divergent metulae, the typically lanceolate and gradually tapered sterigmata in closely parallel arrangement, and the fusiform and elliptical conidia with typically smooth walls.

These strains are clearly separable into two types (as shown in Tables C–17 and M–16) on the basis of pigmentation of the reverse and surrounding agar and size of conidia and sterigmata.

They differ more or less from the descriptions cited above in the mostly fusiform conidia, the sterigmata 9.3 to 10.6 μ in length in some strains, and in the conidia, 3.2 to 4.4 μ long in some strains.

Other cultures, FAT 1366 and FAT 1367, received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, (their No. NRRL 1036 and NRRL 1175) as *P. islandicum* Sopp, duplicated almost exactly the description of *P. islandicum* (FAT 946) as given above.

* Sopp, O., Monograph. pp. 161–164, Taf. XVII, fig. 122; Taf. XXIII, figs. 25 and 26. 1912.

** Thom, C., The Penicillia, pp. 466–467. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 623–625. 1949.

P. verruculosum Peyronel.

FAT 1314, 301, 961, 665, 671, 354, 356, 370.

The colony characteristics and microscopic characters are shown in Tables C–17 and M–16, respectively. Electron micrograph is shown in Fig. E–12.

The strains are assigned to *P. verruculosum* Peyronel (1913*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the rather rapidly spreading growth, the typically or slightly funiculose colonies, the white, yellow, pink or reddish-brown aerial mycelium, the yellow green conidial areas, the brownish reverse, the colorless or tardily weak dull cinnamon surrounding agar, the biverticillate and asymmetrical penicilli, the comparatively short conidiophores with walls smooth or nearly so, the compact or somewhat divergent metulae, the lanceolate and sharply tapered conidium-bearing tubes and closely parallel sterigmata, and conidia globose to subglobose in some strains and mostly ovate in others, with verruculose or granular walls.

These strains are clearly separable into four types, as shown in Tables C–17 and M–16, on the basis of surface characters, color of conidial areas, pigments developed in the reverse and surrounding agar, and the form of conidia.

However, they differ markedly from the descriptions cited above in the usually ovate conidia, mostly 3.0 to 4.3 or 4.5 μ in length.

Another culture, FAT 1388 was received in 1955 from Dr. K. Kominami and M. K. Tubaki, Nagao Institute, (their No. 6016) as *P. echinosporum* Nehira**** (1933) of the Lanata-typica in the Asymmetrica; the strain is considered synonymous with *P. verruculosum*. It duplicated the characters of that species and, in addition, its conidia show delicately echinulate or verruculose walls in electron microscopy (Fig. E–43).

* Peyronel, B., I germi atmosferici dei fungi con micelio, p. 22, Padova, 1913.

** Thom, C., The Penicillia, p. 474. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Peaicillia, pp. 621–623. 1949.

**** Nehira, T., J. Ferm. Tech. Osaka, p. 861. Vol. 11. 1933.

P. varians Smith.

FAT 1209, 949, 379, 380.

The colony characteristics and microscopic characters are shown in Tables C–17 and M–16, respectively.

The strains are assigned to *P. varians* Smith (1933*; Raper, Thom and Fennell, 1949**) because of the restricted or rapidly spreading growth, the typically funiculose or slightly funiculose colonies, the yellow green conidial areas, the vinaceous, brown of becoming dull green reverse, the colorless or pale yellow surrounding agar, the biverticillate and symmetrical penicilli, the smooth or punctate walled conidiophores, sometimes arising from short cells suggesting the foot-cells of *Aspergillus*, the loosely compact or somewhat divergent arrangement of metulae, the lanceolate sterigmata with conidium-bearing tubes characteristically tapered, in closely parallel arrangement, and the ovate or elliptical conidia with walls smooth or nearly so.

These strains are clearly separable into two types as shown in Tables C–17 and M–16, on the basis of rate of growth, colors of the reverse and aerial mycelium, length of sterigmata, and character of the conidiophore walls.

However, they differ from the descriptions cited above in the rather rapidly spreading growth in some strains, and also in length of the sterigmata, mostly 9.8 to 13.0 μ.

* Smith, G., Brit. Mycol. Soc. Trans. 18: 39–90; Pl. IV, fig. 3. 1933.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 625–627. 1949.

P. purpurogenum Stoll.

FAT 1211, 1143, 376, 1149, 722, 48, 1306, 76, 1179, 1074, 47, 1141, 377, 1072, 1073.

The colony characteristics and microscopic characters are shown in Tables C–18 and M–17, respectively.

The strains are assigned to *P. purpurogenum* Stoll (1904*; Thom 1910, 1915, 1930**; Raper, Thom and Fennell, 1949***) because of the rather restrictedly spreading growth, the typically velvety or velutinous colonies in some

strains, floccose or subfloccose in others, the white, yellow, pink, orange or reddish aerial mycelium, the white, yellow, orange or orange-red margin, the typically yellow green conidial areas, the strongly red or purplish red reverse and surrounding agar, the smooth or slightly granular walls of the conidiophores, the biverticillate and symmetrical penicilli, the closely parallel arrangement of metulae, the typical lanceolate and characteristically tapered sterigmata in parallel arrangement, and the elliptical or fusiform to subglobose conidia with smooth or slightly punctate walls.

These strains are clearly separable into three types, as shown in Tables C–18 and M–17, on the basis of colors of aerial mycelium and margin, character of the walls of conidia and conidiophores, and also in the texture and sporulating areas of colonies. In some strains, sporulating areas are limited or localized; in others they are not.

Some other strains produce abundant pigmented steril mycelium FAT 1141, many orange areas; FAT 377, orange or Flame Scarlet; FAT 1027, 1073, Salmon Orange, Grenadine or Dragon's Blood Red in the sterile broad areas.

However, the strains differ more or less from the descriptions cited above in the typical closely parallel arrangement of metulae, and in the fact that no colored mycelium was produced during two years from some newly isolated strains, in the lack of conidia showing distinct transverse bands, and in the slightly granular walls of conidiophores in some strains.

Strains FAT 47, and FAT 48 were received in 1949 from the Sakaguchi Laboratory, University of Tokyo, (their Nos. R, K. 25–6 and 25–7) as *Penicillum* and FAT 76 was received in 1949 from Mr. T. Hasegawa, Institute for Fermentation. Osaka, as a *Penicillium*.

Other cultures, FAT 1368 and 1369, received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, (their No. 6051 and 6045) as *P. sanguineum* Sopp and *P. purpurogenum* Stoll, FAT 1459, received in 1955 from M. T. Hasegawa, Institute for Fermentation, Osaka (their No. 4684) as *P. sangıneum* Sopp, FAT 221, received in 1955 from the Sakaguchi Laboratory, University of Tokyo, (their No. P–3–4) as Red Pilz. Noda Sanken. 18.10, duplicated almost exactly the description of *P. purpurogenum* as given above.

* Stoll, O., Beitrage zur morphologischen und biologischen Charackteristrik Penicilliumarten, Wurzburg, p. 35, Taf. I. fig. 7, Taf. III, fig. 3. Taf. IV, fig. 4. 1904.

** Thom, C., U. S. Dept. Agr., Bur. Anim. Ind., Bul. 118, p. 39, fig. 7, 1910; and Mycologia 7: 134–142. 1915; The Penicillia, pp. 478–479. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 633–636. 1949.

P. rubrum Stoll.

FAT 1147, 727, 1154, 1145.

The colony characteristics and microscopic characters are shown in

Tables C–18 and M–17, respectively.

The strains are assigned to *P. rubrum* Stoll (1904*; Thom, 1910, 1930**; Raper, Thom and Fennell***, 1949) because of the restricted growth, the restricted growth, the typically velvety colonies, the yellow or gray-green conidial areas, the colorless or typically yellow or pink aerial mycelium, the typically strongly reddish reverse and surrounding agar, the biverticillate and symmetrical penicilli, the smooth or nearly so conidiophore walls, the loosely compact or somewhat divergent arrangement of metulae. the lanceolate sterigmata with apices tapered, in loosely compact arrangement, and the elliptical, fusiform to ovate conidia with walls smooth or nearly so.

These strains are clearly separable into three types, as shown in Tables C–18 and M–17, on the basis of color of mycelium, character of the margin, colors of the conidial areas, and characters of the colony surface.

They differ markedly from *P. purpurogenum* Stoll in the usually somewhat divergent metulae, the rate of growth and other characters.

* Stoll, O., Beitrage zur morphologischen und biologischen Charackteristik Penicilliumarten, Wurzberg, p. 35, Taf. I, fig. 7, Taf. III, fig. 3, Taf. IV, fig. 4. 1904.

** Thom, C., U. S. Dept. Agr., Bur. Anim. Ind., Bul. 118, p. 39, fig. 7. 1910; The Penicillia, p. 476. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 637–639. 1949.

P. aculeatum Raper and Fennell.

FAT 810.

The colony characteristics and microscopic characters are shown in Tables C–18 and M–17, respectively. An electron micrograph is shown in Fig. E–44.

The strain is assigned to *P. aculeatum* Raper and Fennell (1948*. 1949**) because of the typically velvety colony character, the yellow green conidial areas, the deep-red or purplish-red reverse, the colorless, becoming light pink-orange, surrounding agar, the yellow pink or reddish mycelium, the punctate or small granular walled conidiophores, the biverticillate and symmetrical penicilli, the definitely inflated and suggestively divaricate arrangement of metulae, the loosely compact or somewhat divergent sterigmata, lanceolate and somewhat swollen, and the globose to subglobose conidia with conspicuously echinulate or verruculose walls.

However, the strain differs somewhat from the description (cited above) in the rather rapidly spreading growth, and the definitely inflated and suggestive divaricate-like arrangement of its metulae.

* Raper, K. B. and Fennell, D. I., Mycologia, 40: 535–538, fig. 10. 1948.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 639–642. 1949.

P. aculeatum Raper and Fennell var. *apiculatum* Abe.*

FAT 1152, 1207, 1189, 199, 645.

The colony characteristics and microscopic characters are shown in Tables C–18 and M–17, respectively. A colony's photograph and electron micrographs are shown in Figs. C–28 and E–45, 46, respectively.

Colonies on Czapek agar grow rather rapidly, about 40 to 50 mm. in 10 to 12 days at 25°C, consisting of a comparatively thin basal felt bearing crowded conidial structures, some strains subfloccose, others slightly funiculose, often with a vinaceous or pinkish cast from a limited overgrowth of red-pigmented hyphae, near Russet Vinaceous, Peach Red, Light Orange or Flesh Pink shades, with a yellow or light pink margin, 1.5 to 2.5 mm. wide, conidial areas in bright or dark yellow green shades near Civette Green, Cedar, Dark Yellowish Green or Dull Blackish Green, becoming Olivaceous Black with age; exudate limited and pale pink or lacking; odor almost lacking; reverse in vinaceous or reddish shades, becoming near Brick Red, Pompeian Red or Morrocco Red, with surrounding agar colorless or becoming pale similar shades; conidiophores arising from the substratum, basal felt or aerial hyphae, variable in length, commonly up to 30 to 60 or 200 μ in length by 2.3 to 3.3 μ in diameter, with smooth or slightly granular walls, apices up to 3.7 to 4.7 μ in diameter; penicilli typically biverticillate and symmetrical, definitely inflated and suggestive divaricate, usually consisting of a single verticils of 6 to 10 to 12 metulae, each terminating in verticils of 5 to 7 or 8 sterigmata; metulae mostly 9.3 to 11.3 to 12.6 μ by 2.3 to 3.3 μ; sterigmata loosely compact or somewhat divergent, mostly 9.3 to 11.0 or 13.1 μ by 2.2 to 3.1 μ, lanceolate in form, characteristically tapered; conidia typically ovate to subglobose with one end apiculate, mostly 3.0 to 3.7 or 4.0 μ by 1.7 to 3.2 μ, with walls conspicuously echinulate or verruculose; conidial chains usually loosely parallel or tangled, up to 30 to 80 μ in length; and conidia showing conspicuously echinulate or verruculose walls in electron microscopy.

Colonies on steep agar grow rather rapidly, 49 to 56 mm. in 10 to 12 days at 25°C; the other characters are as described above, and sometimes the colony surface has a volcanic appearance.

These strains differ markedly from *P. verruculosum* Peyronel** primarily in the production of a strongly reddish color in the reverse.

They differ markedly from the description of *P. aculeatum* Raper and Fennell*** primarily in the rather spreading growth, and in the typically ovate conidia with one end apiculate.

Careful consideration of all described species and varieties of *Penicillium* has failed to reveal on which adequately characterizes the above strains.

The author, therefore, regards the cultures in question as representing a new variety to which the name *P. aculeatum* Raper and Fennell var. *apiculatum* Abe is applied.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). Feb. 1951.

** See, *P. verruculosum* Peyronel.
*** See, *P. verruculosum* Raper and Fennell.

P. purpurogenum Stoll var. *rubri-sclerotium* Thom.

FAT 200, 808, 1210, 325, 316.

The colony characteristics and microscopic characters are shown in Tables C–18 and M–17, respectively.

The strains are assigned to *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom (1915, 1930*; Raper, Thom and Fennell, 1949**) because of the rather rapidly spreading growth, the typically velutinous or slightly funiculose colonies, the white or pale yellowish aerial mycelium, the yellow green conidial areas, the typically reddish shades confined to the central area of the reverse, the colorless agar, the typically biverticillate and symmetrical penicilli, the loosely compact or somewhat divergent arrangement of metulae, the lanceolate sterigmata in loosely parallel arrangement, the elliptical or fusiform conidia with walls smooth or nearly so, and the usually production of abundant dark red or reddish sclerotia in the reverse in about three or four weeks.

However, these strains differ markedly from descriptions cited above in the usually loosely compact or somewhat divergent arrangement of metulae, in the typically punctate or granular conidiophore walls, in the usually colorless or nearly so surrounding agar, in the lack of reddish shades throughout the reverse, and in the rather rapidly spreading growth.

Non-sclerotigenic type:

FAT 1232, 1193, 1148, 324, 1191, 562.

The colony characteristics and microscopic characters are shown in Tables C–18, and M–17, respectively.

Colonies of this type on Czapek and steep agar differ from the others in the entire absence of sclerotia in 5 to 8 week old cultures and in the typically funiculose character of the colonies in some strains.

Thus they are presumed to being to *P. funiculosum* Thom*** rather than *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom, and *P. purpurogeuum* Stoll****.

However, the author finds the strains similar to *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom in all characters except the absence of sclerotia when newly isolated, and they are therefore included in this classification.

The strains are further characterized by luxuriantly growth on Sakaguchi & Wang agar, while *P. funiculosum****, as described above, seldom grows on this medium.

* Thom, C., Mycologia 7: 141–142, fig. 1. 1915; The Penicillia, p. 479, 1930.
** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 636–637. 1949.
, * See, *P. funiculosum* Thom and *P. purpurogenum* Stoll.

P. variable Sopp.

FAT 942, 1175.

The colony characteristics and microscopic characters are shown in Tables C–18 and M–17, respectively.

The strains are assigned to *P. variable* Sopp (1912*; Thom, 1930**; Raper, Thom and Fennell***, 1949) because of the rather rapidly spreading growth, the velutinous colonies, the yellow, pink or reddish colors and abundant production of encrusted sterile hyphae, the dull green conidial areas, the orange-brown shades in reverse, the biverticillate and symmetrical penicilli, the smooth or nearly so conidiophore walls, the loosely compact or divergent arrangement of metulae, the lanceolate and tapered sterigmata in loosely parallel arrangement, and the elliptical conidia with walls smooth or nearly so.

However, they differ somewhat from the descriptions cited above in the sterigmata, mostly 12.1 to 17.0 μ in length, and the rather rapidly spreading growth.

* Sopp, O., Monograph, pp. 169–171; Taf. XVIII, fig. 124; Taf. XXIII, fig. 27. 1912.

** Thom, C., The Penicillia, pp. 477–478. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 642–644. 1949.

P. rugulosum Thom.

FAT 322, 375, 781.

The colony characteristics and microscopic characters are shown in Tables C–19 and M–18, respectively.

The strains are assigned to *P. rugulosum* Thom (1910, 1930*; Raper, Thom and Fennell, 1949**) because of the restricted growth, the typically velvety colonies, the compact admixture of sterile encrusted vegetative hyphae and conidial heads in greater of less abundance, the dark yellow green conidial areas, the reverse showing brown shades in the central area, yellow-orange shades in the marginal areas, becoming typically olive green in the central, brown in subcentral and orange citrine in the marginal areas, the colorless surrounding agar, becoming pale yellow, the biverticillate and symmetrical penicilli, sometimes partly polyverticillate, the loosely compact or somewhat divergent arrangement of metulae, the closely parallel arrangement of acuminate sterigmata, the smooth or nearly so conidiophore walls, and the typically elliptical to ovate conidia with echinulate or verruculose walls.

Conidia also show echinulate or verruculose walls in electron microscopy (Fig. E–47).

However, these strains differ markedly from the descriptions cited above in the typically olive green shades localized in the reverse when newly isolated, the typically echinulate or verruculose walls of the conidia, rarely "conspicuous rugulose walls," and the abundantly sporulating conidial areas

in typicall blackish yellow green colors.

* Thom, C., U. S. Dept. Agr., Bur. Anim. Ind., Bul. 118. pp. 60–61, fig. 21. 1910; The Penicillia, pp. 472–474, figs. 80 and 81. 1930.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 646–650. 1949.

P. concavo-rugulosum Abe.*

FAT 672, 198, 710, 383, 744, 683, 310, 924, 689.

The colony characteristics and microscopic characters are shown in Tables C–19 and M–18, respectively. A colony's photograph and electron micrographs are shown in Figs. C–29 and E–48, 49, respectively.

Colonies on Czapek agar grow rather restrictedly, attaining a diameter of 27 to 37 mm. in 10 to 12 days at 25°C, consisting of a comparatively thin basel felt bearing crowded conidial structures, usually typically velvety, sometimes with yellow encrusted vegetative hyphae, a pale yellow margin 0.5 to 1.3 mm. in wide, conidial areas in bright yellow green or dark yellow green; exudate lacking or limited and light orange; odor almost lacking or indistinct, moldy; reverse in orange, orange-red or orange-brown, either localized or throughout, with surrounding agar seldom pigmented in about 3 weeks; conidiophores arising primarily from the substratum or basal felt, mostly up to 60 to 250 μ or 320 μ in length by 2.5 to 3.8 μ in diameter, with walls smooth or nearly so, apices to 3.1 to 5.0 μ in diameter; penicilli typically biverticillate and symmetrical, usually consisting of single verticiis of 4 to 8 loosely compact or somewhat divergent metulae, each terminating in verticils of 4 tô 6 sterigmata; metulae mostly 10.6 to 17.5 μ by 2.3 to 3.5μ; acnminate closely parallel, mostly 11.0 to 14.0 μ by 1.8 to 2.7 μ, conidia typically long elliptical, mostly 3.1 to 4.3 μ by 2.1 to 3.0 μ, with walls smooth or slightly roughened; conidial chains usually loosely parallel or tangled, up to 60 to 150 μ or 180 μ in length; and conidia showing delicately roughened walls (less than 0.1 μ) in electron microscopy.

Colonies on steep agar grow rather restrictedly, 30 to 42 mm. in 10 to 12 days at 25°C; the other characters are as described above.

These strains differ markedly from *P. rugulosum* Thom** primarily in the typically long elliptical conidia (3.1 to 4.3 μ in the long axis), seldom showing rugulose walls, in colonies mostly 27 to 37 mm. in diameter on Czapek agar and in the somewhat longer (mostly 10.6 to 17.5 μ) metulae.

They also differ markedly from *P. variable* Sopp*** primarily in the colored mycelium compactly admixed with conidial heads, in the lack of prominent areas of sterile yellow aerial mycelium, and in the character of seldom growing at 37°C. Careful consideration of all described speciies of *Penicillium* has failed to reveal one which adequately characterizes the above strains.

The author, therefore, regards the cultures in question as representing a new species, to which the binomial *Penicillium concavo-rugulosum* Abe is applied.

The specific name is taken from the Latin, *concavo-rugulosum* (meaning hollow-rugulosum), and is applied because of the long elliptical conidia with walls smooth or nearly so, occasionally with a hollow appearance (under the microscope), and because of its resemblance to *P. rugulosum*.

Strain FAT 198 was recognized in 1951 from Mr. H. Kawada, Government Forest Experimental Station Japan, as *P. rugulosum* Thom****, but it duplicated FAT 672 almost exactly in cultural and microscopic charteristics.

Another culture, FAT 1326, received in 1955 from Prof. Shoji Shibata, University of Tokyo, (their No. S. M. (O) No. 1 Smith England.) as *P. rugulosum* Thom, duplicated almost exactly the description of *P. concavo-rugulosum* Abe as given above.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). Feb. 1951.

, * See, P. rugulosum Thom and P. variable Sopp.

**** Ohmasa, M., Kawada, H. and Nagashima, A., J. Agr. Chem. Soc. Japan. 24, 3. 114–119. 1951.

P. tardum Thom.

FAT 922, 923, 1183, 1184, 1206, 921, 378, 939, 925, 169.

The colony characteristics and microscopic characters are shown in Tables C–19 and M–18, respectively.

The strains are assigned to *P. tardum* Thom (1930*; Raper, Thom and Fennell, 1949**) because of the rather restricted growth, the typically velvety or velutinous colonies, the usually elevated central area, the wave-like zonation of compact yellow mycelium, the sparse conidial structures, the colorless or pale yellow mycelium, the gray-green dark yellow green or light gray-green conidial areas, the bright yellow or colorless reverse, the colorless or pale yellow shades, tardily pigmented, in the surrounding agar, the typically biverticillate and symmetrical penicilli, the smooth or nearly so conidiophore walls, the loosely parallel or somewhat divergent metulae, the lanceolate and closely parallel sterigmata and the typically elliptical conidia with walls smooth or nearly so.

These strains are clearly separable into three types, as shown in Tables C–19 and M–18, on the basis of size of conidia, the pigmentation of reverse and surrounding agar, the characters of the colony surface, and the length of sterigmata and metulae.

However, they differ somewhat from the descriptions cited above in the conidia 3.0 to 4.4 μ long in some strains, in the sterigmata, 9.3 to 12.5 or 14.5 μ in length, in the usually colorless reverse and surrounding agar, and in the occasional wavelike zonation of the colonies.

Other cultures include FAT 1448, received in 1955 from Prof. J. Fukumoto, Osaka Manufactural Technology Research Institute, (their No. 47) as a *Penicillium*; FAT 1408, received in 1955 from Dr. Y. Kinoshita, Katula Laboratory, University of Niigata, (their No. (4)), as a *Penicillium* isolated from an Uzuriba; FAT 1318, received in 1955 from Mr. I. Kanai, Research

Department of Central Research Institute, Japan Monopoly Corporation Tobacco Research (their No. 10); these strains duplicated almost exactly the description of *P. tardum* as given above.

* Thom, C., The Penicillia, pp. 485–487, fig. 84, 1939.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 651–653. 1949.

P. diversum Raper and Fennell.

FAT 1294.

The colony characteristics and microscopic characters are shown in Tables C–19 and M–18, respectively.

Colonies on Czapek and steep agar, duplicated almost exactly the description of *P. diversum* Raper and Fennell (1949*; Raper, Thom and Fennell, 1949**).

The strain was received in 1952 from Prof. K. Sakaguchi, University of Tokyo, originary sent by Drs. K. B. Raper and D. I. Fennell, University of Wisconsin (NRRL 2121) as *P. diversum* Raper and Fennell.

* Raper, K. B. and Fennell, D. I., Mycologia, 40: 539–541, fig. 11. 1948.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 653–655. 1949.

P. diversum var. *aureum* Raper and Fennell.

FAT 1295.

The colony characteristics and microscopic characters are shown in Tables C–19 and M–18, respectively.

Colonies on Czapek and steep agar are rather restrictedly spreading; pale yellow submerged mycelium, long and sparse, forming a broad margin about 12 mm. wide; conidial areas heavy but restricted to the central area; the other characters duplicated almost exactly the descriptions (Raper and Fennell, 1948*; Raper, Thom and Fennell, 1949**) of *P. diversum* var. *aureum*.

The strain was received in 1952 from Prof. K. Sakaguchi, University of Tokyo, originally sent by Drs. K. B. Raper and D. I. Fennell, University of Wisconsin (NRRL 1074), as *P. diversum* var. *aureum* Raper and Fennell.

* Raper, K. B. and Fennell, D. I., Mycologia, 40; 541–542, fig. 11. 1948.

** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 655–656. 1956.

P. herquei Bainier and Sartory.

FAT 951, 958, 651, 309, 1205, 953, 957, 954, 702, 262, 1028, 1313.

The colony characteristics and microscopic characters are shown in Tables C–20 and M–19, respectively.

The strains are assigned to *P. herquei* Bainier and Sartory (1912*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the restricted character of growth, the typicaly velvety, velutinous or subfloccose colonies,

the bright or dark yellow green conidial areas, the typical bright green, blackish green or olive-brown colors, localized or throughout in the reverse, the pale green yellow or dull yellow surrounding agar, the typically biverticillate and symmetrical penicilli, the suggestively divaricate arrangement of metulae, the conidial tubes tapered abruptly to narrow beak-like, the sterigmata loosely compact or somewhat divergent, the strongly elliptical, near Rugby ball form conidia with walls smooth or nearly so, and conidia showing delicately roughened walls in electron micorscopy (Fig. E–50).

These strains are separable into five types, as shown in Tables C–20 and M–19, on the basis of rate of growth, texture, pigmentation of the reverse, and characters of the margin.

However, they differ more or less from the descriptions cited above in the gradual development of greenish colors in the reverse, becoming typically bright or dark green in 4 weeks or more and in the sterigmata, 10.6 to 14.4 μ in length in some strains.

Other cultures, FAT 1375, 1376 and 1377, received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, as *P. luteo-caerulea* Saito and Minoura**** (1949), (their Nos. 6028, 6029 and 6030) duplicated almost exactly the description of *P. herquei* to given above.

In addition, FAT 1372 and FAT 1373, received in 1955 from Dr. K. Kominami and Mr. K. Tubaki, Nagao Institute, as *P. luteo-viride* Biourge, (their Nos. 6031 and 6032), FAT 1458, received from Mr. T. Hasegawa, Institute for Fermentation, Osaka, as *P. herquei* Bainier and Satory, (their No. 4672) duplicated almost exactly the description given above.

* Bainier, G. and Satory, A., Bul. Soc. Mycol. France 28: 121–126; Pl. VII, figs. 1–10. 1912.

** Thom, C., The Penicillia, pp. 467–469. fig. 78. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 659–664. 1949.

**** Saito, K. and Minoura, K. J. Ferm. Tech. Osaka. 27: 6–7. 1949.

P. novae-zeelandiae van Beyma.

FAT 1296.

The colony characteristics and microscopic characters are shown in Tables C–20 and M–19, respectively.

The strain, received in 1952 from Prof. K. Sakaguchi, University of Tokyo, was originally sent by Drs. K. B. Raper and D. I. Fennell, (their NRRL 2128) as *P. novae-zeelandia* van Beyma.

Colonies on Czapek and steep agar essentially duplicate the descriptions of *P. novae-zeelandiae* van Beyma (1930–1940*; Raper, Thom and Fennell**, 1949).

However, the strain differs more or less from the descriptions of that species in the non production of sclerotia, in conidia, mostly 1.8 to 2.6 μ in diameter, and in loosely compact or somewhat divergent arrangement of metulae.

* van Beyma, F. H., Antonie van Leeuwenhoek 6: 273–275, fig. 7. 1939–1940.
** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 665–667. 1949.

P. paraherquei Abe.*

FAT 971, 964, 824, 670.

The colony characteristics and microscopic characters are shown in Tables C–20 and M–19, respectively.

Colonies on Czapek agar are rather broad, attaining a diameter of 50 to 68 mm. in 10 to 12 days at 25°C, consisting of a comparatively thin basal felt bearing crowded conidial structure; typically velutinous, often wifh a yellow mycelium, with a yellow margin 1.5 to 2.0 mm. wide, smooth; conidial areas in dark yellow green shades near Dusky Olive Green or Dark Green in central area and Dusky Yellowish Green or Antique Green in marginal areas, becoming olive green; exudate lacking or abundant, colorless or pale yellow; odor lacking or limited, moldy; reverse in greenish shades, near Medal Bronze or Aniline Yellow in the central area and Citrine Yellow in the marginal areas, with surrounding agar colorless, becoming weakly yellow; conidiophores arising from the substratum or the basal felt, sometimes from aerial hyphase, variable in length, commonly up to 190 to 240 μ in length by 3.1 to 4.7 μ in diameter, with apices 4.0 to 5.6 μ in diameter, typically granular walled; penicilli typically biverticillate and symmetrical, definitely inflated, usually consisting of a single verticil of 4 to 7 metulae, each terminating in verticils of 4 to 6 sterigmata, metulae mostly 9.3 to 15.6 μ by 2.5 to 4.1 μ, loosely compact or somewhat divergent; sterigmata loosely compact, mostly 8.1 to 10.6 μ by 2.1 to 2.8 μ, characteristically tapered or narrow; conidia elliptical, mostly 2.9 to 3.3 μ by 1.8 to 2.5 μ, with slightly rough walls; conidial chains tangled or loosely parallel, up to 30 to 90 μ in length; and conidia showing delicately echinulate or verruculose walls in electron microscopy. A colony's photograph and an electron micrograph are shown in Figs. C–30 and E–51, respectively.

Colonies on steep agar are restricted or rapidly spreading, 25 to 58 mm. in 10 to 12 days at 25°C, surface radially furrowed; the other characters are as described above. These strains differ markedly from *P. herquei* Bainier and Sartory** primarily in the delicately echinulate or verruculose conidia walls, mostly 2.9 to 3.3 μ in length, in the rather broadly spreading character of growth, and in the infrequent production of a suggestively divaricate arrangement of the metulae.

The strains also differ from *P. olsoni* Bainier and Sartory*** (1912; Thom, 1930; Raper, Thom and Fennell, 1949) in the diameter of its conidiophores less than 4.0 μ. Careful consideration of all described species and varieties of *Penicillium* has failed to reveal one which adequately characterizes the above strains.

The author, therefore, regard the cultures in question as representing a

new species, to which the binomial *P. paraherquei* Abe is applied.

The specific name is taken the Latin, *paraherquei* (meaning modified), and is applied because of the delicately echinulate or verruculose walls of conidia, 2.9 to 3.3 μ in length, in the arrangement of metulae, and also in the broadly spreading growth. The correct placement of the species remains in doubt, but it appears to be most satisfactorily assignable to a series with *P. herquei* Bainier and Sartory in the Symmetrica.

* Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). April. 1953.

** See, *P. herquei* Bainier and Sartory.

*** Bainier, G. and Sartory, A., Ann, Mycol. 10: 398–399; Pl. VI, figs. 1–9. 1912.

P. estinogenum Komatu and Abe*.

FAT 1196, 1195.

The colony characteristics and microscopic characters are shown in Tables C–20 and M–19, respectively. A colony's photograph and an electron micrograph are shown in Figs. C–31 and E–52, respectively.

Colonies on Czapek agar grow rather rapidly, spreading, attaining a diameter of 40 to 50 mm. in 10 to 12 days at 25°C, consisting of a comparatively hard and thin basal felt bearing crowded conidial structures, typically velvety, with surface radially furrowed, a white margin about 1.0 mm. wide, conidial areas dark yellow green shades, near Dark American Green becoming Ivy Green or Light Brownish Olive; exudate limited, in pale yellow shades; odor lacking or limited, moldy; reverse in dull yellow or olive shades, becoming olive in the central area and brownish or brownish olive in the marginal areas; surrounding agar yellow or pale greenish; conidiophores arising primarily from the substratum or from basal felt, commonly 90 to 180 μ in length by 2.5 to 5.2 μ in diameter, with apices 4.0 to 5.9 μ in diameter, and slightly roughened walls; penicilli biverticillate and symmetrical, usually consisting of a single verticil of 4 to 6 metulae, each terminating in verticils of 4 to 7 sterigmata, metulae mostly 10.0 to 15,2 μ in length by 2.4 to 3.6 μ in diameter, loosely compact or somewhat divergent; sterigmata compact, mostly 8.0 to 12.0 μ by 2.1 to 3.0 μ, and narrowly tapered; conidia elliptical or ovate, mostly 3.0 to 4.0 μ by 2.5 to 3.1 μ, with granular or verruculose walls; conidial chains tangled or loosely parallel, up to 60 to 130 μ in length; and conidia showing granular or verruculose walls in electron mioroscopy,

Colonies on steep agar grow rather broadly, 46 to 62 mm. in 10 to 12 days at 25°C; the other characters are as described above.

These strains differ markedly from *P. herquei* Bainier and Sartory** (1912; Thom, 1930; Raper, Thom and Fennell, 1949) primarily in the typically granular or verruculose conidial walls, in the infrequent production of beak-like sterigmata, and in the rarely observed suggestively divaricate arrangement of metulae.

The strains also differ markedly from *P. novae-zeelandiae* van Beyma*** primarily in the typical elliptical form and granular or verruculose walls of

the conidia. Therefore, since they cannot be satisfactorily assigned to any other described form, the author considers them as representing a new species to which the binomial *P. estinogenum* Komatu and Abe is assigned.

The specific name is taken from the Latin, *estinogenum* (meaning Estin-producing), and is applied because of the new antibacterial substance "Estin" found in this species by Mr. E. Komatu (1953).

The correct placement of the species remains in doubt, but it appears to be most satisfactorily assignable to a series with *P. herquei* Bainier and Sartory in the Biverticillata-Symmetrica as in the classification of Raper, Thom and Fennell (1949).

* Komatsu, E. and Abe, S., Paper read before the Agr. Chem. Soc. Japan (Tokyo). April. 1953.

** See, *P. herquei* Bainier and Sartory.

*** See, *P. novae-zeelandiae* van Beyma.

Polyverticillata

P. albicans Bainier.

FAT 1316.

The colony characteristics and microscopic characters are shown in Tables C–21 and M–20, respectively.

The strain is assigned to *P. albicans* Bainier (1907*; Thom, 1930**; Raper, Thom and Fennell, 1949***) because of the somewhat broadly spreading growth which is very sparse on Czapek agar but usually luxuriant on steep agar, the slightly funiculose colonies, the cream or pinkish conidial areas, the light brownish reverse, the smooth or nearly so conidiophore walls, the polyverticillate penicilli, variable in size and pattern, commonly very large, and with 3 to 5 branches below the sterigmata, cellular elements closely packed, very compact and smooth walled, the branches and metulae variable in form and size and compact in arrangement, the closely compact sterigmata variable in length, with conidium-bearing tips somewhat narrowed, the strongly elliptical conidia with basal ends somewhat flattened and walls smooth or nearly so and loosely divergent conidial chains.

However, the strain differs somewhat from the descriptions cited above in the size and length of conidiophores and cellular elements of the penicilli, and in the size of conidia.

This strain, received in 1954 from Mr. K. Tubaki, Nagao Institute, (their No. 6289) as *P. albicans* Bainier, was isolated from filter paper.

* Bainier, G., Bul. Soc. Myc. France 23: 18, Pl. V, figs. 8 and 9. 1907.

** Thom, C., The Penicillia, p. 495. fig. 87. 1930.

*** Raper, K. B., Thom, C. and Fennell, D. I., A Manual of the Penicillia, pp. 669–672. 1949.

PART II. BIOCHEMICAL CHARACTERISTICS

1. RATE OF GROWTH

Sopp[1] (1912) gave the optimum temperature of every strain described in his Monograph. Sakaguchi (1930) described the optimum temperatures of 21 strains of *Citromyces*, 20 of which grew luxriantly at 20° to 30°C, and one of which grew at 35°C; 14 of the strains couled not grow at 37°C, and four strains could no grow at 5°C. Sakaguchi, Iizuka and Yamazaki[2] (1949) described the amount of growth at 27° to 28°, 32 to 33°, 37° to 38°, 43° and 48°C for all strains of the *Aspergillus niger* group; all strains could grow at 27° to 43°C, a few at 46°C, and none at 48°C.

In Rhizopus, this character is used for classification, but most investigators have not used it for classification of the Penicillia.

Therefore, the author investigated the rate of growth of all strains listed in this systematic morphological classification, and has obtained results which are useful for classification.

Experimental Method

Strains: All strains of *Penicillium* listed in the section on systematic morphological classification.

Culture medium: Czapek agar and steep agar, as previously described.

Determination of the rate of growth: The diagnostic culture usually employed was a spot inoculation of an agar plate with masses of conidia from a selected area of a Czapek agar slant which had been incubated at 25°C for 7 days.

The petri dishes were incubated in the dark at 5°, 15°, 25°, 30° and 37°C for 22 to 30 days. Two or three plates of each sort were usually made.

The character of growth of each strain was observed, and the colony diameter of each strain was measured on the 5th, 10th and 20th days.

Results and Discussion

The diameter of the colonies of all strains grown at 25°, 30° and 37°C are shown in Tables C-1 to 16 and of those grown at 5° and 15°C, in Tables B-1 to 5.

Some strains are not described in Tables B-1 to 5; these have the same character as the described ones. Colonies grown at 5°, 15°, 30° and 37°C, however, were measured, but not described on the 5th and 20th days, because these measurements were not important.

Diameters of colonies grown at 5° 15°C on Czapek agar are described, but the diameters on steep agar are not given as they were almost the same as on the other. The diameters of colonies grown as 25°, 30° and 37°C on Czapek agar as shown in Table B, are shown overlapping in Table C to make comparison easy. (See, Table 9)

At 5°C, about two-thirds of the 127 Monoverticillata strains did not grow, and about one-third developed irregular colonies less than 10 mm. in diameter. About one-third of the 65 strains of the Divaricata of the Asymmetrica did not grow, but about 47 strains developed irregular colonies less than 10 mm. in diameter.

The character of growth is characteristic in individual species or varieties; although it is not useful in the separation of series and sections it is somewhat useful in the separation of species or varieties.

In the Velutina subsection of the Asymmetrica, no strains of the *P. citrinum* series grew characteristically, but all the strains of other series were more or less distinctive. Accordingly, this character is useful in the separation of series, and in this way *P. paxilli* Bainier was assigned to the *P. citrinum* series, although Raper, Thom and Fennell had assigned it to the *P. brevi-compactum* series. In the Fasciculata, all the strains showed growth and developed colonies less than 30 mm. in diameter. The character of limited colony size is somewhat useful in the separation of sections.

In the Biverticillata-Symmetrica, *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom, *P. rugulosum* Thom, *P. paraherquei* Abe, *P. estinogenum* Komatu and Abe, showed growth (less than 3 mm. in diameter), but the others did not.

This character is somewhat useful in the separation of sections. One strain in the Polyverticillata did not grow at this temperature.

Therefore the character of growth at 5°C is somewhat useful in the separation between the *P. citrinum* series and the others in the Velutina subsection, between the Fasciculata subsection and the others, and between the Biverticillata-Symmetrica section and the others.

At 15°C, all strains in the Monoverticillata, Velutina and Divaricata of the Asymmetrica, Biverticillata-Symmetrica and Polyverticillata, showed growth, but usually developed colonies less than half the diameter of those grown at 25°C.

But colonies of all strains of the Fasciculata of the Asymmetrica developed colonies as large as those grown at 25°C or slightly smaller.

The character of growth at 15°C, is, however, not useful in the separation series, subsections and sections, but in the Fasciculata it is somewhat useful in separating subsections or sections.

At 25°C, the diameters of colonies of strains in the Monoverticillata were between 8 and 80 mm. Separation on the basis of restrictedly spreading, rapidly spreading, or broadly spreading growth is somewhat useful in separating species or varieties.

The diameter of colonies of strains of the Divaricata subsection of the Asymmetrica were between 22 and 80 mm. Colony growth is not useful in separating series or subsections; it is somewhat useful only in separating species or varieties.

The colony diameters of strains of the Velutina subsection in the Asym-

Table 9. Diameters of colonies after

Section and Subsections	Temperature of Culture	Agar Medium	0 mm.	1–10 mm.	11–20 mm.	21–30 mm.	31–40 mm.	41–50 mm.	51–60 mm.	61–70 mm.	71–80 mm.	81 mm.
Monoverticillata	5°C	Czapek	79	48	0	0	0	0	0	0	0	0
		Steep	79	48	0	0	0	0	0	0	0	0
	15°C	Czapek	0	12	50	37	24	4	0	0	0	0
		Steep	0	12	46	39	25	5	0	0	0	0
	25°C	Czapek	0	1	6	42	25	9	9	20	15	0
		Steep	0	1	2	24	33	22	5	9	30	1
	30°C	Czapek	0	1	5	42	27	19	22	9	2	0
		Steep	0	1	6	26	30	20	20	20	4	0
	37°C	Czapek	122	3	1	0	0	1	0	0	0	0
		Steep	122	2	2	0	0	1	0	0	0	0
Asymmetrica Divaricata	5°C	Czapek	18	47	0	0	0	0	0	0	0	0
		Steep	18	47	0	0	0	0	0	0	0	0
	15°C	Czapek	0	0	20	27	18	0	0	0	0	0
		Steep	0	0	18	25	22	0	0	0	0	0
	25°C	Czapek	0	0	0	0	11	18	25	8	3	0
		Steep	0	0	0	1	3	15	23	18	5	0
	35°C	Czapek	0	0	1	3	11	20	20	10	0	0
		Steep	0	0	1	1	4	18	16	18	7	0
	37°C	Czapek	23	32	5	5	0	0	0	0	0	0
		Steep	23	28	9	5	0	0	0	0	0	0
Asymmetrica Velutina	5°C	Czapek	61	86	17	1	0	0	0	0	0	0
		Steep	61	86	17	1	0	0	0	0	0	0
	15°C	Czapek	0	55	62	18	17	6	7	0	0	0
		Steep	0	50	60	20	19	8	8	0	0	0
	25°C	Czapek	0	0	0	7	39	57	29	21	12	0
		Steep	0	0	1	1	15	46	53	29	13	7
	30°C	Czapek	0	0	2	9	53	61	28	1	11	0
		Steep	0	0	0	9	22	54	48	21	10	1
	37°C	Czapek	150	5	3	3	0	2	1	1	0	0
		Steep	154	1	4	2	0	0	4	0	0	0

10 to 12 days at various temperatures

Section and Subsections	Temperature of Culture	Agar Medium	0 mm.	1–10 mm.	11–20 mm.	21–30 mm.	31–40 mm.	41–50 mm.	51–60 mm.	61–70 mm.	71–80 mm.	81 mm.
Asymmetrica Fasciculata	5°C	Czapek	0	39	38	6	0	0	0	0	0	0
		Steep	0	35	40	8	0	0	0	0	0	0
	15°C	Czapek	0	0	3	10	43	23	4	0	0	0
		Steep	0	0	3	9	44	22	5	0	0	0
	25°C	Czapek	0	0	0	3	8	34	25	13	0	0
		Steep	0	0	0	7	13	20	20	16	7	0
	30°C	Czapek	0	1	9	29	24	18	2	0	0	0
		Steep	0	1	10	23	14	18	12	5	0	0
	37°C	Czapek	83	0	0	0	0	0	0	0	0	0
		Steep	83	0	0	0	0	0	0	0	0	0
Symmetrica	5°C	Czapek	92	15	0	0	0	0	0	0	0	0
		Steep	92	15	0	0	0	0	0	0	0	0
	15°C	Czapek	0	77	20	10	0	0	0	0	0	0
		Steep	0	75	22	10	0	0	0	0	0	0
	25°C	Czapek	0	2	9	36	22	17	13	7	1	0
		Steep	0	3	5	20	23	18	22	12	4	0
	30°C	Czapek	0	3	8	27	30	10	18	5	6	0
		Steep	0	3	2	27	18	14	19	15	9	0
	37°C	Czapek	46	26	21	4	7	2	1	0	0	0
		Steep	46	32	6	13	4	4	0	0	0	0
Polyverticillata	5°C	Czapek	1	0	0	0	0	0	0	0	0	0
		Steep	1	0	0	0	0	0	0	0	0	0
	15°C	Czapek	0	1	0	0	0	0	0	0	0	0
		Steep	0	1	0	0	0	0	0	0	0	0
	25°C	Czapek	0	0	0	0	1	0	0	0	0	0
		Steep	0	0	0	0	0	0	0	1	0	0
	30°C	Czapek	0	0	0	1	0	0	0	0	0	0
		Steep	0	0	0	0	1	0	0	0	0	0
	37°C	Czapek	1	0	0	0	0	0	0	0	0	0
		Steep	1	0	0	0	0	0	0	0	0	0

metrica are between 20 and 85 mm.; strains of the *P. citrinum* series have diameters between 20 and 50 mm., and strain of *P. oxalicum* Currie and Thom developed colonies about 80 mm, in diameter. These sizes are characteristic. The character is not useful in separating series, however, but is somewhat useful in separating species.

The colony diameters of strains of the Fasciculata are between 30 and 70 mm. in diameter; in this group, the character of growth is somewhat useful in separating species, but not in separating series or subsections.

The colony diameters of strains of the Biverticillata were between 4 and 78 mm. All strains of the *P. rugulosum* series showed "restricted" growth, *P. rubrum* Stoll showed "restrictedly spreading" growth, and strains of *P. funiculosum* Thom and *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom showed "broadly spreading" growth; these are characteristic.

Only one strain in the Polyverticillata showed "rapidly or broadly spreading" growth.

The character of growth at 25°C, is somewhat useful in separating the *P. citrinum* series from the others in the Velutina, and the *P. rugulosum* series from the others in the Biverticillata-Symmetrica, and it is useful in separating species (or varieties) as well.

In the cultures grown at 30°C, colonies of *Penicillium* showed growth characteristics which are not distinguishable from those of colonies grown at 25°C.

Thus, this character is not sufficiently distinctive to be useful in classification of strains or species.

At 37°C, the Monoverticillata strains of *P. thomii* Maire, *P. chermesinum* Biourge, *P. sublateritium* Biourge and *P. fellutanum* Biourge var. *nigro-castaneum* Abe grew characteristically, but the others did not grow.

In the Divaricata subsection, the strains of *P. lilacinum* Thom and *P. janthiuellum* Biourge grew characteristically, but the others did not grow.

In the Velutina subsections, the strains of *P. oxalicum* Currie and Thom and *P. casei* Staub grew characteristically, but the others did not grow.

In the Fasciculata subsection, no strains grew. In the Biverticillata-Symmetrica, no strains of the *P. rugulosum* and the *P. herquei* series grew, but the other strains did. On strain of the Polyverticillata did not grow.

Therefore the character of growth at 37°C is useful in separating series in the Biverticillata-Symmetrica, and it is somewhat useful in separating species in the other sections or subsections.

The strains of *Penicillium* generally grew somewhat more luxuriantly and spread more broadly on steep agar than on Czapek agar, but the following strains of a few spread more luxuriantly or broadly on Czapek agar than on steep agar; *P. viridicatum* Westling, FAT 818, 851, 999, 1273; *P. stoloniferum* Thom, FAT 694, 815, 1202, 507, 90, 709; *P. diversum* Raper and Fennell, FAT 1294; *P. diversum aureum* Raper and Fennell, FAT 1295;

and *P. tardum* Thom, FAT 169.

Raper, Thom and Fennell (1949) stated that this character can be used in separating the *P. frequentans* and the *P. lividum* series, and other series in the Monoverticillata, but it is mostly used in separating species only.

The character remained constant after incubation for 10 to 12 days, and even after cultivation for about five years no characteristice differences were found.

In addition, the fluctuation of the colony diameter was usually less than one-tenth of the diameter of each strain. The rate of growth of each strain generally was characteristic of the individual except when artifical variation or mutation was induced. Therefore, the author considers this character useful and important as a basis of separation in classification of the *Penicillia*.

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II. ASSIMILATION OF NITRITE

Sakaguchi and Wang[1–4] (1934, 1936) described a medium which is useful in the classificcation of fungi; this medium is stable and will bear sterilization or long preservation. With the aid of this medium the Aspergillus niger group was divided into the following three group: growing well, growing somewhat and growing little. Sakaguchi, Iizuka and Yamazaki[5] (1949, 1950) and Iizuka[6] (1953) have reported that the *Aspergillus niger* group could be divided into two group: strains which grew on the above medium as well as on the common synthetic medium during incubation at 30°C for three days, and strains which did not grow or grew only slightly after 10 days of incubation. *Aspergillus awamori* did not grow on Sakaguchi & Wang agar containing 0.15% $NaNO_2$ at pH 2 to 7.4; strain R-0221 of *Asp. awamori* grew normally at pH 2 to 3.8, but not over pH 5.3 (ajusted with HCl, citric acid and oxalic acid); strains R-0635 of *Asp. usami* and R-0436 of *Asp. inui* grew normally at pH 2 to 7.4.

Whether a strain of the *Aspergillus niger* group assimilates nitrite or not was used as an aid for classification of the niger group.

The author has investigated the growth of all strains on Sakaguchi & Wang agar, and obtained results useful for the classification of the *Penicillia* as well as for the *Aspergillus niger* group.

Experimental Method

Strains: All strains of *Penicillia* listed in the systematic morphological classification.

Culture medium: Sakaguchi & Wang agar: Sucrose, 30 gms.; $NaNO_2$, 1,5 gms.; K_2HPO_4, 1.0 gm.; $MgSO_4 \cdot 7H_2O$, 0.5 gm.; KCl, 0.5 gm.; $FeSO_4 \cdot 7H_2O$, 0.01 gm.; distilled water 1 liter; agar, 20 gms.: The pH is adjusted to 7.0, and then the medium is sterilized at 120°C for 15 minutes.

Determination of the rate of growth: The diagnostic culture usually employed was a spot inoculation of an agar plate or a streak inoculation of an agar slant with masses of conidia from a selected area of a Czapek agar slant which had been incubated at 25°C for 7 days. The petri dishes and agar slants were incubated at 25°C for 7 to 10 days. For this study two plates or slants of each strain were usually made. The growth characters of each strain were observed on the 7th and 10th days.

Results and Discussion

The character of assimilation of Nitrite by all strains is shown in Table B-1 to 5, and strains which are not described in the Table have the same character as the described ones.

The degree of growth was characterized as follows: growing little or not, (−); growing fairly well, +; growing and slightly sporulating, ++; growing very well, +++.

The species, varieties and mutations of the *Penicillia* which grew little or not on Sakaguchi and Wang agar, are shown below.

Growing little or not on Sakaguchi and Wang agar.

1) *P. thomii* series ..... *P. sclerotiorum* van Beyma.
2) *Mono-globosa* series .... *P. lilacino-echinulatum* Abe.
   P. frequentans Westling.
   P. multicolor G.-M. and P.
   P. roseo-purpureum Dierckx.
   P. terlikowskii Zaleski.
3) *Mono-elliptica* series .... *P. chermisinum* Biourge.
   P. implicatum Biourge.
   P. sublateritium Biourge.
   P. adametzioides Abe.
   P. fellutanum Biourge var. *nigro-castaneum* Abe.
4) *P. nigricans* series..... *P. nigricans* (Bainier) Thom.
   P. nigricans (Bainier) Thom var. *sulfuratum* Abe.
5) *P. chrysogenum* series .. *P. chrysogenum* Thom.
   P. chrysogenum Thom mut. *fulvescens* Takashima, Arima and Abe.
   P. meleagrinum Biourge.
   P. notatum Westling.
   P. cyaneo-fulvum Biourge.

6) *P. roqueforti* series ....*P. casei* Staub.
P. casei Staub var. *compactum* Abe.
7) Fasciculata-Subsection ..All species, varieties or mutations except *P. martensii* Biourge, *P. italicum* Wehmer and *P. clavigerum* Demelius.
8) *P. funiculosum* series...*P. funiculosum* Thom.
P. islandicum Soop.
9) *P. albicans* series.....*P. albicans* Bainier.

These strains were easily separated from the other strains which showed fair growth. Accordingly, whether or not strains may grow on this agar is useful as a basis of classification.

The problem of the specific activity of each starin at various pH's and the reason for their failure to grow on this agar will be described in a future report.

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III. ANTIBACTERIAL OR ANTIFUNGAL ACTIVITY

Since penicillin was discovered by Dr. Alexander Fleming[1] in 1928, many antibacterial or antifungal activities of the Penicillia have been desbribed by numerous investigators; citrinin, claviformin, clavacin, patulin, curling factor, fumigatin, spinulosin, gliotoxin, mycophenolic acid, notatin, penatin, penicillic acid, penicillin, viridin, frequentin, phoenicin, griseofulvin, corylophilin, penicidin, gladiolic acid, carneolutescin, puberulic acid, 6-methy-salicylic acid, tardin, and others were isolated from the *Penicillia* between 1928 and 1949. Curtis, Hemming, and Unwin[2] (1951) reported the isolation of a antibacterial, anti-yeast and antifungal red pigment, "Albidin" from *P. albidum*.

Bernhauer and Rauch[3] (1949) described that the nutrient medium is

very important in antibiotic formation, and examined 165 out 375 *Penicillium* species for activity. Gorbach, Vicari and Dedic[4] (1949) described the elucidation of the inhibitory factor and its formation in *Penicillium expansum*.

Darken and Sjolander[5] (1951) described the production of patulin by *Penicillium urticae*. Grove[6] (1953) described the structure and fungistatic activity of gladiolic acid from *P. gladioli*. Jefferys, Brian, Hemming and Lowe[7] (1953) described the antifungal and antibacterial antibiotics from *P. citrinum*, *P. frequentans*, *P. nigricans*, *P. terlikowskii* and *P. roqueforti*, which were isolated from acid heath soils. Johnson Kidwai and Warner[8] (1954) described the gliotoxin acetate from *P. terlikowskii*, and Pentz[9] (1954) described 49 *Penicillia* which inhibited the growth of *Staphylococcus*, *Bacillus subtilis* and *E. coli*.

The author has investigated the correlation between antibiotic formation and the systematic classification of the *Penicillia* by the agar disk method, with various test organisms.

Experimental Method

Strains:

One or two strains of each species, variety or mutant of *Penicillium* listed in the systematic morphological classification.

Culture media:

1. Sucrose Czapek steep agar:
   Sucrose, 30 gm.; $NaNO_3$, 3.0 gms.; $MgSO_4 \cdot 7H_2O$, 0.5 gm.; KCl, 0.5 gm.; K_2HPO_4, 1.0 gm.; $FeSO_4 \cdot 7H_2O$, 000.1 gm.; $CuSO_4 \cdot 7H_2O$, 0.005 gm.; corn steep liquor, 10 gms.; distilled water, 1 liter; agar, 30 gms.. The pH was adjusted to 7.0 with NaOH before sterilization.
2. For test organism:
   A. Glucose Bouillon:
      Glucose, 10 gms.; peptone, 5 gms.; malt extact, 5 gms.; NaCl, 5 gms.; distilled water, 1 liter; agar, 20 gms.. The pH was adjusted to 7.4 with NaOH before sterilization.
   B. Glycerine Bouillon agar:
      Glucose, 20 gms.; peptone, 10 gms.; malt extract, 5 gms.; NaCl, 5gms.; distilled water, 1 liter; agar, 20 gms.. The pH was adjusted to 7.0 with NaOH before sterilization.
   C. Subroud agar:
      Glucose, 20 gms.; peptone, 5 gms.; malt extract, 50 gms. distilled water, 1 liter; ager, 20 gms.. The pH was adjusted to 5.8 to 6.0 with NaOH before sterilization. When ready to use the pH was adjusted to 8.0 with NaOH.
   D. Malt extract agar:
      Described previously.
   E. Czapeck agar:
      Described previously.

Determination of the antibacterial or antifungal activity:

The sucrose Czapek steep agar was poured into a petri dish, and inoculated in a single streak with one loop of spores from cultures which had been incubated for 7 days on Czapek agar. The petri dishes were incubated in the dark at 25°C for 5 days. The agar disk was scooped out (by a cork borer with an inside diameter of 10 mm.) at the margin or near it, where a colony had developed from a streak. The agar-disk was set on an agar plate for testing, and them incubated.

The antibacterial activities against *Staphylococcus aureus* 209 P, *Bacillus subtilis*, and *Escherichia coli*, were determined by measuring the diameter of the inhibition zone on glucose Bouillon agar after incubation for 24 hours at 37°C.

The antibacterial activity against *Mycobacterium* 607 was measured by the diameter of the inhibition zone on Glycerine bouillon agar after incubation for 48 hours at 37°C.

The antibacterial activity against *Candida albicans* Yu 1200 was measured by the inhibition zone on Subroud agar after incubation for 24 hours at 30°C.

The anti-yeast activity against *Saccharomyces cerevisiae* was measured by the inhibition zone on malt agar after incubation for 48 hours at 30°C.

The antifungal activity against *Aspergillus oryzae* was measured by the inhibition zone on Czapek agar after incubation for 48 hours at 30°C.

The plates were used for each sample, and the average value of inhibition zones was taken.

Results and Discussion

The antibacterial, antiyeast or antifungal activities of the *Penicillia* are shown in Table B–1 to 5 respectively.

Although many reports or antifungal or antibacterial activities of the *Penicillia* have been presented, the following antimicrobial activities either differ from previous descriptions or they have never been reported.

1. *P. thomii* Maire var. *flavescens* Abe produces a substance inhibitory *Staphylococcus aureus* 209 P, *Bacillus subtilis* and *Escherichia coli*.
2. *P. cinnamopurpureum* Abe, *P. purpurrescens* (Sopp) Raper, Thom and Fennell and *P. trzebinskii* Zaleski produce a substance inhibitory to *Staphylococcus aureus* 209 P and *Escherichia coli*.
3. *P. multicolor* G.-M. and P. and *P. decumbens* Thom produce a substance inhibitory to *E. coli*.
4. *P. decumbens* Thom var. *atro-virens* Abe produces a substance inhibitory to *Staphylococcus aureus* 209 P.
5. *P. admetzioides* Abe produces a substance inhibitory to *Mycobacterium* 607.
6. *P. lilacino-echinulatum* Abe produces a substance inhibitory to *Staphylococcus aureus* 209 P, *Bacillus subtilis*, *E. coli*, and *Saccharomyces cerevisiae*.

7. *P. lilacinum* Thom produces a substance inhibitory to *Saccharomyces cerevisiae*.
8. *P. ochro-choloron* Biourge produces a substance inhibitory to *Staph. aureus*, *B. subtilis*, and *E. coli*.
9. *P. echinulo-nalgiovense* Abe produces a substance inhibitory to *Staph. aureus* 209 P, *E. coli* and *Saccharomyces cerevisiae*.
10. *P. corylophiloides* Abe produces a substance inhibitory to *Staph. aureus* 209 P and *Asp. oryzae*.
11. *P. citreo-virens* Abe produces a substance inhibitory to *Staph. aureus* 209 P. only, and which differs markedly from that of *P. citrinum* and the *P. sterkii* species.
12. *P. meleagrinum* Biourge var. *viridi-flavum* Abe produces a substance inhibitory to *Staph. aureus* 209 P, *B. subtilis* and *E. coli*, and which is similar to that of the *P. chrysogenum* series.
13. *P. citrinum* Thom produces a substance inhibitory to *Candida albicans* Yu 1200, but *P. steckii Zaleski* does not produce such a substance.
14. *P. oxalicum* Currie and Thom produces a substance inhibitory to *B. subtilis* and *Candida albicans* Yu 1200.
15. *P. digitatum* Saccardo var. *latum* Abe produces a substance inhibitory to *Staph. aureus* 209 P and *Mycobacterium* 607.
16. *P. brevi-compactum* Dierckx, *P. stoloniferum* Thom and *P. brunneo-stoloniferum* Abe produce a substance inhibitory to *Candida albicans* Yu 1200, but *P. paxilli* Bainier does not.
17. *P. palitans* Westling var. *echinoconidium* Abe produces a substance inhibitory to *Staph. aureus* 209 P aad *E. coli*, but *P. cyclopium* Westling var. *echinulatum* Raper Fennel does not.
18. *P. viridi-cyclopium* Abe produces a substance inhibitory to *Staph. aureus* 209 P, *B. subtilis*, *E. coli*, *S. cerevisiae* and *Asp. oryzae*.
19. *P. verruculosum* Peyronel produces a substance inhibitory to *Staph. aureus* 209 P, *B. subtilis*, *E. coli*, *Mycobacterium* 607 and *Asp. oryzae*.
20. *P. purpurogenum* Stoll and *P. rubrum* Stoll inhibits *Staph. aureus* 209 P only, but *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom inhibits *Staph. aureus* 209 P, *E. coli*, *Candida albicans* and *Asp. oryzae*.
21. *P. rugulosum* Thom inhibits *Staph. aureus* 209 P only, but *P. concavo-rugulosum* Abe inhibits *Staph. aureus* 209 P, *Saccharomyces cerevisiae* and *Asp. oryzae*.
22. *P. paraherquei* Abe produces substance inhibitory to *Staph. aureus* 209 P, *B. subtilis* and *Candida albicans*.
23. From *P. estinogenum* Komatu and Abe, Komatu has isolated the new antibacterial substance named "Estin".

In the Monoverticillata, the *Ramigena* series was not inhibitory to all test organisms, but all other strains except *P. sclerotiorum* van Beyma, *P. restrictum* Gilman and Abbott, *P. fuscum* (Sopp) Raper, Thom and Fennell, *P. citreo-viride* Biourge var. *aeneum* Abe, *P. multicolor* G.-M. and P., *P.*

roseo-purpureum Dierckx, *P. trzebinskii* Zaleski var. *magnum* Sakaguchi and Abe, *P. chermesinum* Biourge, *P. phoeniceum* van Beyma, *P. sublateritium* Biourge, *P. adametzioides* Abe, *P. decumbens* Thom and *P. fellutanum* Biourge var. *nigro-castaneum* Abe were inhibitory to *Staph. aureus* 209 P.

P. terlikowskii Zaleski and *P. trzebinskianum* Abe and *P. lilacino-echinulatum* Abe had strong inhibitory activity.

Strains of a few species were inhibitory to *B. subtilis*; *P. lilacino-echiuulatum* Abe, *P. terlikowskii* Zaleski and *P. trzebinskianum* Abe were strongly active against it.

Strains of many species were inhibitory to *E. coli* but their activity was weak. Only *P. citreo-virde* Biourge was inhibitory to *Candida albicans* Yu 1200, and its activity was weak.

Only *P. terlikowskii* Zaleski and *P. adametzioides* Abe were inhibitory to *Mycobacterium* 607, and their activities were weak.

Only *P. lilacino-echinulatum* Abe and *P. terlikowskii* Zaleski were inhibitory to *Sacch. cerevisiae*, and no strains of the Monoverticillata were inhibitory to *Asp. oryzae*.

Each species or variety was shown to have a characteristic inhibition pattern but these characters cannot be used in the separation of series and sections.

In the Divaricata-subsection of the Asymmetrica, a few species were inhibitory to *Staph. aureus* 209 P, but their activities were not strong.

Strains of a few species were also inhibitory to *B. subtilis* and *E. coli*, but their activities were not strong either. No strains were inhibitory to *Candida albicans* or *Mycobacterium* 607. A few strains were inhibitory to *Sacch. cerevisiae*, but *P. lilacinum* Thom was the only one which had a strong activity. Only this strain was inhibitory to *Asp. oryzae*, as well, and it had rather strong activity.

In the Velutina subsection of the Asymmetrica, all strains of the *P. citrinum*, *P. chrysogenum*, *P. brevi-compactum* and *P. digitatum* series produced substances inhibitory to *Staph. aureus*, but the *P. oxalicum* series and *P. roqueforti* Thom and *P. roqueforti* Thom var. *punctatum* Abe were not inhibitory; the strains of the *P. chrysogenum* series, however, had very strong activity.

No strains of the *P. brevi-compactum* and the *P. digitatum* series, *P. citreo-virens* Abe, *P. corylophilum* Dierckx, *P. corylophiloides* Abe, *P. paxilli* Bainier in the *P. citrinum* series, *P. atramentosum* Thom, *P. roqueforti* Thom, *P. roqueforti* Thom var. *punctatum* Abe and *P. casei* Staub were inhibitory to *B. subtilis*, but strains of the *P. chrysogenum* series had very strong activity.

All strains of the *P. chrysogenum* series except *P. chrysogenum* Thom, and all strains of the *P. brevi-compactum* series, *P. casei* Staub and *P. pseudo-casei* Abe were inhibitory to *E. coli*, but their activity was not strong.

All strains of the *P. brevi-compactum* series, *P. citrinum* Thom and *P. oxalicum* Currie and Thom were inhibitory to *Candida albicans*; *P. brevi-compactum* Dierekx and *P. stoloniferum* Thom were strongly active. In the Velutina subsection only *P. digitatum* Saccardo var. *latum* Abe produced a substance inhibitory to *Mycobacterium* 607. No strains in this subsection were inhibitory to *Sacch. cerevisiae*.

Some strains of *P. steckii* Zaleski, *P. corylophiloides* Abe, *P. stoloniferum* Thom, and *P. brunneo-stoloniferum* Abe were inhibitory to *Asp. oryzae*, and the last two were strongly active. *P. roqueforti* Thom and *P. roqueforti* Thom var. *P. punctatum* Abe were not inhibitory to any test organisms.

In the Fasciculata subsection, *P. ochraceum* Thom, *P. crustosum* Thom, *P. viridicatum* Westling and *P. claviforme* Demelius were not inhibitory to *Staph. aureus* 209 P., but the following species were strongly active: *P. viridi-cyclopium* Abe, *P. urticae* Bainier, *P. expansum* Thom, *P. martensii* Biourge and *P. claviforme* Bainier.

Among the few species inhibitory to *B. subtilis*, the following were strongly active; *P. urticae* Bainier, *P. expansum* Thom and *P. claviforme* Bainier.

Many strains were inhibitory to *E. coli*, and the following were strongly active; *P. viridi-cyclopium* Abe, *P. urticae* Bainier, *P. martensii* Biourge and *P. claviforme* Bainier. While many strains in the Fasciculata were not inhibitory to *Candida albicans*, *P. martensii* Biourge and *P. claviforme* Bainier and its mutants were somewhat inhibitory to *Candida albicans*.

P. ochraceum, *P. crustosum*, *P. viridi-cyclopium* and the *P. granulatum* series were not inhibitory to *Mycobacterium* 607, but many strains of the *P. urticae-italicum* and the *P. claviforme* series were strongly active.

Many strains of *P. viridi-cyclopium* Abe, *P. urticae* Bainier, *P. expansum* Thom, *P. martensii* Biourge, and *P. claviforme* Bainier or its mutants were inhibitory to *Sacch. cerevisiae*, and some strains of *P. claviforme* Bainier or its mutants were strongly active. Some strains of *P. viridi-cyclopium* Abe, *P. cyclopium* Westling var. *chinulatum* Raper and Fennell, *P. expansum* Thom, *P. martensii* Biourge, and *P. claviforme* Bainier and its mutants were inhibitory to *Asp. oryzae*, and *P. claviforme* Bainier was strongly active.

In the Biverticillate-Symmetrica, all strains except *P. wortmanni* Klöcker, *P. duclauxi* Delacroix, *P. novae-zeelandiae* van Beyma and *P. variable* Sopp, were inhibitory to *Staph. aureus* 209 P; the following especially active: *P. tardum* Thom and *P. estinogenum* Komatu and Abe.

Some strains of *P. funiculosum* Thom, *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom, *P. tardum* Thom and *P. estinogenum* Komatu and Abe, were strongly active against *B. subtilis*, and some strains of *P. tardum* Thom and *P. herquei* Bainier and Sartory were strongly active against *E. coli*. In addition, some strain of *P. duclauxi* Delacroix, *P. varians* Smith,

P. purpurogenum Stoll var. *rubri-sclerotium* Thom, *P. herquei* Bainier and Sartory, *P. paraherquei* Abe were inhibitory to *Candida albicans* Y 1200.

A few species of *P. purpurogenum* and the *P. funiculosum* series and *P. tardum* Thom were inhibitory to *Mycobacterium* 607, and *P. funiculosum* and *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom most strongly inhibited this bacterium.

P. duclauxi Delacroix, *P. variable* Soop and *P. concavo-rugulosum* Abe were inhibitory to *Saccharomyces cerevisiae*, and *P. duclauxi* Delacroix was strongly active.

In *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom, *P. concavo-rugulosum* Abe and *P. herquei* Bainier and Sartory, some strains were strongly inhibitory to *Asp. oryzae*. Although this activity is not useful for separating series, it may be used separating species in the following groups; *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom and the non-sclerotigenic type; *P. rugulosum* Thom and *P. concavo-rugulosum* Abe; and *P. herquei* Bainier and Sartory and *P. paraherquei* Abe.

In the Polyverticillata only *P. albicans* was inhibitory *Staph. aureus* 209 P. It is clear that antibiotic activity is a distinguishing character of individual strains, species, varieties and mutants of the *Penicillia*, and some species or series were shown to have a specific activity against test organisms.

Since this activity differs from strain to strain, the activity is cannot from a basis of classification of series or sections, but it is somewhat useful in separating strain or varieties.

The discovery of antibacterial or antifungal activities of many strains of *Penicillium*, which had never been described before, is quite noteworthy.

The determination of the nature of these unknown antibiotics is problem to be examined in future study.

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IV. BROTH COLORING MATTER

Each species and strain of the *Penicillia* is shown to have specific pigmentation in the reverse and surrounding agar on Czapek or steep agar, as shown in Table C–1 to 12.

The pigmentation may be yellow, orange, red, brown, lilac, violet, purple, green, black, or other shades. Of course this pigment production may be altered changing the nutrient composition of the substratum and by other culture conditions.

Raper, Thom and Fennell (1949) reported that in some strains the substratum was quickly discolored and the color change of the mycelium followed, but in other strains the color was retained within the hyphal cells; the difference is often believed to reflect minor changes in biochemical reactions rather than difference of fundamental importance.

Within recent years Raistrick and others have initiated a study of the pigments produced by the *Penicillia*; Birkinshaw[1] (1952), Munekata[2] (1953), Lulla and Johar[3] (1954), Howard and Raistrick[4] (1954), Galarraga, Neill and Raistrick[5] (1955), Shibata, Tanaka and Kitagawa[6] (1955), Takashima, Kitajima and Otuka[7] (1955) have reported on the subject.

Several of the pigments described act as indicators, changing color when the reaction is shifted from acid to alkaline and vice versa.

Color and color changes of broth pigments with changes of pH have not been reported, however, for the various *Penicillia* listed in our systematic morphological classification.

The extraction of some pigments by various solvents has been described by Raistrick and other investigators, but, this study had not previously been made systematically. Therefore, the color reactions of broth pigments at pH 2, 7 and 9 were investigated in detail, and the extraction of broth pigments by various solvents was studied to determine whether these might be useful for classification.

Experimental Method

Strains: One or two strains of each species of *Penicillium* in our systematic morphological classification.

Culture: Conical flasks volume 300 ml, each containing 120 ml of Czapek

solution (sucrose, 30 gms.; $NaNO_3$, 3.0 gms.; K_2HPO_4, 1.0 gm.; $MgSO_4 \cdot 7H_2O$, 0.5 gm.; KCl, 0.5 gm.; $FeSO_4 \cdot 7H_2O$, 0.01 gm.; distilled water, 1 liter) were plugged with cotton and were inoculated with one loopful of spores of each strain which had been incubated for 7 days on Czapek agar. The flasks were incubated in the dark at 25°C for 22 to 23 days.

Estimation of the color and color changes and the extraction by various solvents at pH 2, 7 and 9.:

1. The culture filtrate (25 ml) was poured into three 15×170 mm. test tubes. These were adjusted to pH's 2, 7 and 9 with H_2SO_4 and NaOH, determined by a Beckman pH meter.

   The color and color changes of each sample and the color of the precipitates were described according to Ridgway's color tables.

2. Sample solution of 2 ml were poured into 12×80 mm. test tubes, with caps. To each, 1.0 to 1.5 ml of one of these solvents; chloroform, butyl alcohol, ethyl acetate, benzene, and ligroin, was added, the solution was shaken 40 times, and then extracted. The degree of extraction of the broth coloring matter was estimated in this way.

3. To make other tests, 2.0 ml of a sample solution were poured into a 20 ml vessel for freeze-drying, and then dried at 45°C for three to five hours; after this 1.0 to 1.5 ml of one of these solvents was added; ethanol, acetone, glacial acetic acid, and pyridine, and the solution was extracted. In this way the degree of extraction of the broth coloring matter was estimated.

Results and Discussion

The colors and color changes of broth at pH's 2, 7 and 9 are shown in Tables S–1 to 4.

1. Eighteen species and varieties were shown to have colorless broth or nearly so at pH 2, 7 and 9, as they do on Czapek agar.

Monoverticillata.

1. *P. lividum* Westling.....FAT 877, 626.
2. *P. trzebinskii* Zaleski var. *magnum* Sakaguchi and Abe.....FAT 24.
3. *P. decumbens* Thom. .....FAT 208, 604.
4. *P. decumbens* Thom var. *atro-virens* Abe ....FAT 329, 1140.
5. *P. fellutanum* Biourge. .....FAT 767, 9.
6. *P. fusco-flavum* Abe. .....FAT 1081.
7. *P. cyaneum* Biourge.....FAT 741.
8. *P. charlesii* Smith var. *rapidum* Abe. .....FAT 831, 734, 806.
9. *P. velutinum* van Beyma. .....FAT 1121.
10. *P. aurantio-violaceum* Biourge. .....FAT 1008, 561.

Asymmetrica.

11. *P. simplicissimum* (Oud) Thom. .....FAT 883, 768.
12. *P. citreo-virens* Abe. .....FAT 319, 320.
13. *P. paxilli* Bainier.....FAT 1286.

Symmetrica.

14. *P. wortmanni* Klöcker. .....FAT 364.
15. *P. verruculosum* Peyronel. .....FAT 1114.
16. *P. aculeatum* Raper and Fennell. .....FAT 810.
17. *P. diversum* Raper and Fennell.....FAT 1294.
18. *P. albicans* Bainier. .....FAT 1316.

2. The broth of the following strains was pale or weakly or distinctly pigmented, but the surrounding agar was seldom pigmented on Czapek medium.

		Color or shades of broth.
A. Monoverticillata.		
1. *P. spinulosum* Thom	FAT 668, 639.	Pale Yellowish.
2. *P. fellutanum* Biourge var. *nigro-castaneum* Abe.	FAT 623, 624.	near English Red.
3. *P. restrictum* Gilman and Abbott.	FAT 779.	Pale Yellow.
4. *P. velutinum* van Beyma	FAT 891	Weakly Yellow.
B. Divaricata.		
5. *P. janthinellum* Biourge	FAT 1097.	Mars Yellow or Antimony Yellow.
6. *P. ochro-chloron* Biourge.	FAT 906	Primrose Yellow.
7. *P. piscarium* Westling.	FAT 881, 905	Pale Yellow.
8. *P. jenseni* Zaleski.	FAT 770.	Pale Yellow.
9. *P. nigricans* Thom var. *sulfuratum* Abe.	FAT 536.	Pale Yellow.
10. *P. melinii* Thom.	FAT 581, 992.	Pale Yellow.
C. Velutina.		
11. *P. corylophiloides* Abe.	FAT 984, 308.	Amber, or Massicot Yellow.
12. *P. steckii* Zaleski	FAT 509, 715.	Pale Yellow.
13. *P. meleagrinum* Biourge.	FAT 1222.	Strongly Yellow.
14. *P. meleagrinum* Biourge var. *viridi-flavum* Abe.	FAT 652, 803.	Yellow or Pink.
15. *P. cyaneo-fluvum* Biourge	FAT 699, 573.	Bright Yellow.
16. *P. digitatum* Saccardo var. *latum* Abe.	FAT 605.	Yellow.
17. *P. roqueforti* Thom	FAT 733, 1253	Pale Yellow.
18. *P. roqueforti* Thom var. *compactum* Abe.	FAT 314, 315.	Weakly Yellow.
19. *P. pseudo-casei* Abe.	FAT 317, 1166	Pale Yellow.

20. *P. casei* Staub var. *compactum* Abe. .....FAT 1276. .....Pale Yellow.

D. Fasciculata.

21. *P. ochraceum* Thom. .....FAT 766. .....Yellow or Orange.
22. *P. palitans* Westling .....FAT 985, 838. .....Yellow or Brownish.
23. *P. cyclopium* Westling. ....FAT 1052, 840.....Yellow or Bright Yellow.
24. *P. cyclopium* Westling var. *echinulatum* Raper and Fennell.....FAT 987.....Pale Yellow.
25. *P. puberulum* Bainier. ....FAT 1304, 1262. ....Weakly Yellow.
26. *P. crustosum* Thom. .....FAT 703, 1058, 318. .Yellow or Pale Orange.
27. *P. italicum* Wehmer. .....FAT 774. .....Weakly Yellow.
28. *P. corymbiferum* Westling .FAT 606. .....Pale Pinkish or Pale Yellow.

E. Biverticillata-Symmetrica.

29. *P. funiculosum* Thom. .....FAT 71, 1267.....Pale Orange or Orange Brown.
30. *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom. ....FAT 1210, 325.....Salmon.
31. " (Non-sclerotigenic type)..FAT 1148, 562.....Salmon Orange or Reddish.
32. *P. concavo-rugulosum* Abe..FAT 672, 744. .....Pale Yellow.
33. *P. diversum* var. *aureum* Raper ond Fennell.....FAT 1295. .....Weakly Yellow.

3. The broth of the following strains was pale and weakly pigmented, or not pigmented at all, but the surrounding agar was distinctly pigmented on Czapek medium.

A. Monoverticillata.

On Czapek agar.

1. *P. thomii* Maire var. *flavescens* Abe.....FAT 340. .....Pale Yellow Green.
2. *P. frequentans* Westling....FAT 627, 1032.....Yellow or Pinkish.

B. Asymmetrica.

3. *P. janthinellum* Biourge....FAT 1156, 217.....Pinkish or Reddish.
4. *P. miczіuskii* Zaleski. .....FAT 882, 908.....Amber Yellow.
5. *P. canescens* Sopp. .....FAT 832. .....Lilac or Dull Yellow.

4. Broth pigments precipitated at the bottom at pH 2 and 9.

	Strain No.	pH 2.	pH 9.
1. *P. chermesinum* Biourge..	FAT 1287.....	Hays Maroon.	Mars Violet.

2. *P. purpurogenum* Stoll. ..FAT 1143, 76.Buret Sienna. English Red. or or Morroco Red. Brazil Red.

3. *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom. (Non-sclerotigenic type)...FAT 1148.....None.....Salmon Orange.

5. Broth pigments precipitated at the bottom at pH 2.

	Strain No.	Color of PPT.
A. Monoverticillata.		
1. *P. cinnamopurpureum* Abe.	FAT 363, 362.	Morroco Red.
2. *P. multicolor* G.-M. and P.	FAT 1051.	Raw Sienna.
3. *P. fellutanum* Biourge var. *nigro-castaneum* Abe.	FAT 623.	Bay.
	FAT 624.	Victoria Lake.
4. *P. roseo-purpureum* Dierckx.	FAT 780.	Bay.
	FAT 1288.	Old Gold.
5. *P. restrictum* Gilman and Abbott.	FAT 779.	Colonial Buff.
6. *P. terlikowskii* Zaleski	FAT 776, 1290	Morocco Red.
7. *P. phoeniceum* van Beyma.	FAT 1292.	Victoria Lake.
B. Asymmetrica.		
8. *P. nalgio-echinulatum* Abe.	FAT 907.	Vinaceous Rufous.
	FAT 884.	Light Brownish Yellow.
9. *P. nigricans* Thom.	FAT 948.	Flame Scarlet.
10. *P. citrinum* Thom.	FAT 600.	Picric Yellow.
11. *P. chrysogenum* Thom.	FAT 1020, 914.	Light Cadmium Yellow.
12. " var. *fulvescens* Takashima, Arima and Abe.	FAT 515	Yellow Ocher
13. *P. casei* Staub	FAT 817, 1030	Buckthorn Brown.
14. *P. viridi-cyclopium* Abe.	FAT 998.	Vinaceous Cinnamon.
15. *P. martensii* Biourge	FAT 1201.	Sanford Brown.
16. *P. expansum* (Link) Thom.	FAT 736.	Clay Color.
	FAT 740.	Cadmium Yellow.
17. *P. urticae* Bainier.	FAT 1314, 1315.	Mars Yellow.
18. *P. claviforme* Bainier mut. *candicans* Abe and Ura.	FAT 1277.	Xanthine Orange.
19. *P. claviforme* Bainier mut. *olivicolor* Abe and Ura.	FAT 1278.	Xanthine Orange.
C. Biverticillata-Symmetrica.		
20. *P. duclauxi* Delacroix	FAT 1293.	Old Gold.
21. *P. verruculosum* Peyronel	FAT 961	Raw Sienna.

22. *P. varians* Smith.....FAT 1209. .....Light Salmon Orange.
23. *P. rubrum* Stoll.....FAT 1145. .....Raw Umber.
24. *P. variable* Sopp. .....FAT 942, 1175.....Sudan Brown.
25. *P. rugulosum* Thom. .....FAT 322, 375. .....Raw Sienna.
26. *P. herquei* Bainier and
    Sartory.....FAT 958. .....Medal Bronze.
    〃 ....FAT 1313. .....Light Cadmium Yellow.
27. *P. paraherquei* Abe. .....FAT 824. .....Naples Yellow.
28. *P. estinogenum* Komatu
    and Abe. .....FAT 1196, 1195. ....Raw Sienna.

Extraction of coloring matter from the broth of surface cultured strains with various solvents.

The extraction of coloring matter from the broth of surface culture at pH 2, 7 and 9 is shown in Tables S-1 to 4.

By the specific extractability of coloring matter with various solvents at these pH's strains of each species or varieties were separated as described below. The degree of extraction was described as follows; seldom extracted, −; slightly extracted, about one-fourth extracted, +; about one-half extracted, ++; about three-fourths extracted, +++; completely extracted, ++++.

(1) Chloroform.

(1. All coloring matter was extracted at pH 2.

A. Monoverticillata.
1. *P. purpurrescens* (Sopp) Raper, Thom and Fennell.
2. *P. trzebinskianum* Abe.
3. *P. fellutanum* Biourge var. *nigro-castaneum* Abe.
4. *P. citreo-viride* Biourge.
5. *P. citreo-viride* Biourge var. aeneum Abe.
6. *P. phoeniceum* van Beyma.

B. Asymmetrica.
7. *P. janthinellum* Biourge.
8. *P. ochro-chloron* Biourge.

C. Symmetrica.
9. *P. rugulosum* Thom.

(2. All the coloring matter was extracted at pH 7 and 9.
1. *P. trzebinskianum* Abe. (not at pH 9)
2. *P. citreo-viride* Biourge.....FAT 960.
3. *P. citreo-viride* Biourge var. *aeneum* Abe.....FAT 122.

(3. Seldom extracted.
1. *P. spinulosum* Thom.
2. *P. adametzioides* Abe.

3. *P. capsulatum* Raper and Fennell.
4. *P. velutinum* van Beyma.
5. *P. lilacinum* Thom.
6. *P. janthinellum* Biourge.
7. *P. corylophilum* Thom.
8. *P. corylophiloides* Abe.
9. *P. chrysogenum* Thom.
10. *P. chrysogenum* Thom mut. *fulvescens* Takashima, Arima and Abe.
11. *P. oxalicum* Currie and Thom.
12. *P. atramentosum* Thom.
13. *P. roqueforti* Thom.
14. *P. casei* Staub var. *compactum* Abe.
15. *P. aurantio-virens* Biourge.
16. *P. urticae* Bainier.
17. *P. corymbiferum* Westling.
18. *P. granulatum* Bainier.
19. *P. verruculosum* Peyronel.
20. *P. varians* Smith.
21. *P. aculeatum* Raper and Fennell var. *apiculatum* Abe.
22. *P. diversum* var. *aureum* Raper and Fennell.
23. *P. novae-zeelandiae* van Beyma.

(2) Butyl alcohol.

(1. All coloring matter was extracted at pH 2.
Numerous strains.

(2. Seldom extracted.....None.

(3. All coloring matter was extracted at pH 7 and 9.
1. *P. citreo-viride* Biourge.....FAT 960.
2. *P. citreo-viride* Biourge var. *aeneum* Abe.....FAT 122.
3. *P. thomii* Maire.

(4. Seldom extracted at pH 7 and 9.
1. *P. spinulosum* Thom.
2. *P. implicatum* Biourge. (only at pH 9)
3. *P. chermesinum* Biourge.
4. *P. adametzioides* Abe.
5. *P. terlikowskii* Zaleski. (only at pH 9)
6. *P. lilacino-echinulatum* Abe.
7. *P. vinaceum* Gilman and Abbott.
8. *P. capsulatum* Raper and Fennell.
9. *P. velutinum* van Beyma.
10. *P. lilacinum* van Beyma.
11. *P. piscarium* Westling.
12. *P. ochro-chloron* Biourge (only at pH 9)
13. *P. echinulo-nalgiovensis* Abe.

14. *P. nigricans* Thom var. *sulfuratum* Abe.
15. *P. corylophilum* Dierckx.
16. *P. corylophiloides* Abe.
17. *P. chrysogenum* Thom.
18. *P. chrysogenum* Thom mut. *fulvescens* Takashima, Arima and Abe.
19. *P. oxalicum* Currie and Thom.
20. *P. atramentosum* Thom (only at pH 9)
21. *P. digitatum* Saccardo var. *latum* Abe.
22. *P. roqueforti* Thom.
23. *P. casei* Staub.
24. *P. pseudo-casei* Abe.
25. *P. casei* Staub var. *compactum* Abe.
26. *P. brunneo-stoloniferum* Abe.

Fasciculata and Symmetrica.....Numerous strains.

(3) Ethyl ether.

(1. Seldom extracted.
1. *P. implicatum* Biourge.
2. *P. adametzioides* Abe.
3. *P. lilacinum* Thom.
4. *P. nigricans* Thom var. *sulfulatum* Abe
5. *P. corylophilum* Dierckx.
6. *P. corylophiloides* Abe.
7. *P. oxalicum* Currie and Thom.
8. *P. brevi-compactum* Dierckx.
9. *P. stoloniferum* Thom.
10. *P. aurantio-virens* Biourge.
11. *P. urticae* Bainier.
12. *P. clavigerum* Demelius.

Symmetrica.....None.

(2. Somewhat extracted at pH 9.
1. *P. thamii* Maire.
2. *P. trzebinskianum* Abe.
3. *P. multicolor* G.-M. and P.
4. *P. citreo-viride* Biourge.
5. *P. citreo-viride* Biourge var. *aeneum* Abe.
6. *P. roseo-purpureum* Dierckx.
7. *P. phoeniceum* van Beyma.
8. *P. chrysogenum* Thom.
9. *P. meleagrinum* Biourge var. *viridi-flavum* Abe.
10. *P. cyaneo-fulvum* Biourge (FAT 699)
11. *P. brunneo-stoloniferum* Abe.

Fasciculata in Asymmetrica, and Biverticillata-Symmetrica. ....None.

(4) Ethyl Acetate.

(1. Seldom extracted at any pH.
1. *P. lilacino-echinulatum* Abe.
2. *P. nigricans* Thom var. *sulfuratum* Abe.
3. *P. corylophilum* Dierckx.
4. *P. pseudo-casei* Abe.
5. *P. aurantio-virens* Biourge.

(2. Somewhat extracted at pH 9.
1. *P. thomii* Maire.
2. *P. trzebinskianum* Abe.
3. *P. multicolor* G.-M. and P.

4. *P. sublateritum* Bainier.
5. *P. fellutanum* Biourge var. *nigro-castaneum* Abe.
6. *P. citreo-viride* Biourge.
7. *P. citreo-viride* Biourge var. *aeneum* Abe.
8. *P. roseo-purpureum* Dierckx.
9. *P. phoeniceum* van Beyma.
10. *P. chrysogneum* Thom.
11. *P. meleagrinum* Biourge.
12. *P. meleagrinum* Biourge var. *viridi-flavum* Abe.
13. *P. notatum* Westling.
14. *P. stoloniferum* Thom.
15. *P. brunneo-stoloniferum* Abe.
16. *P. viridicatum* Westling.
17. *P. cyclopium* Westling.
18. *P. islandicum* Westling.

(5) Benzene.

(1. Not extracted at any pH.

1. *P. cinnamopurpureum* Abe.
2. *P. purpurrescens* (Sopp) Raper, Thom and Fennell.
3. *P. spinulosum* Thom.
4. *P. adametzioides* Abe.
5. *P. lilacinum* Thom.
6. *P. nigricans* Thom var. *sulfuratum* Abe.
7. *P. corylophilum* Dierckx.
8. *P. corylophiloides* Abe.
9. *P. chrysogenum* Thom.
10. *P. chrysogenum* Thom mut. *flavescens* Takashima, Arima and Abe.
11. *P. oxalicum*, *P. digitatum*, *P. roqueforti*, *P. brevi-compatum* series. (except *P. roqueforti* Thom and var. *punctatum* Abe)
12. *P. ochraceum* Thom.
13. *P. viridicatum* Westling.
14. *P. aurantio-virens* Biourge.
15. *P. urticae* Bainier.
16. *P. corymbiferum* Westling.
17. *P. granulatum* Bainier.
18. *P. claviforme* Bainier.
19. *P. claviforme* Bainier mut. *candicans* Abe and Ura.
20. *P. claviforme* Bainier mut. *olivicolor* Abe and Ura.
21. *P. duclauxi* Delacroix.
22. *P. funiculosum* Thom.
23. *P. verruculosum* Peyronel.
24. *P. varians* Smith.
25. *P. purpurogenum* Stoll.....(FAT 1143)
26. *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom.

27. *P. rubrum* Stoll.
28. *P. aculeatum* Raper and Fennell var. *apiculatum* Abe.
29. *P. concavo-rugulosum* Abe.
30. *P. diversum* var. *aureum* Raper and Fennell.
31. *P. paraherquei* Abe.
32. *P. novae-zeelandiae* van Beyma.

(2. Somewhat extracted at pH 9.
1. *P. thomii* Maire.
2. *P. trzebinskianum* Abe.
3. *P. multicolor* G.-M. and P.
4. *P. citreo-viride* Biourge.
5. *P. citreo-viride* Biourge var. *aeneum* Abe.
6. *P. roseo-purpureum* Abe.
7. *P. islandicum* Sopp.

(6) Ligroin.
(1. Somewhat extracted at pH 2.
1. *P. thomii* Maire.
2. *P. trzebinskianum* Abe.
3. *P. implicatum* Biourge.
4. *P. multicolor* G.-M. and P.
5. *P. fellutanum* Biourge var. *nigro-castaneum* Abe.
6. *P. citreo-viride* Biourge var. *aeneum* Abe.
7. *P. terlikowskii* Zaleski.
8. *P. vinaceum* Gilman and Abbott.
9. *P. janthinellum* Biourge.
10. *P. ochro-chloron* Biourge.
11. *P. echinulo-nalgiovense* Abe.
12. *P. melinii* Thom.
13. *P. citrinum* Thom.
14. *P. steckii* Zaleski.
15. *P. chrysogenum* Thom.
16. *P. meleagrinum* Biourge.
17. *P. melargrinum* Biourge var. *viridi-flavum* Abe.
18. *P. notatum* Westling.
19. *P. cyaneo-fulvum* Biourge.
20. *P. islandicum* Sopp.
21. *P. rugulosum* Thom.
22. *P. herquei* Bainier and Sartory.

(7) Ethanol.
(1. Perfectly extracted.
1. *P. citreo-viride* Biourge.
2. *P. lilacinum* Thom.
3. *P. echinulo-nalgiovense* Abe.

4. *P. expansum* Thom.
5. *P. purpurogenum* Stoll.
6. *P. rugulosum* Thom.

(2. Seldom extracted.....None.

(8) Acetone.

(1. Perfectly extracted.

P. expansum Thom.

(2. Seldom extracted.....None.

(9) Glacial acetic acid.

All of the strains were slightly or perfectly extracted.

(10) Pyridine.

(1. Perfectly extracted.

1. *P. citreo-viride* Biourge.....FAT 960.
2. *P. citreo-viride* Biourge var. *aeneum* Abe.....FAT 122.
3. *P. urticae* Bainier. .....FAT 1315.
4. *P. crustosum* Thom.....FAT 318.
5. *P. varians* Smith. .....FAT 1209.
6. *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom.FAT 1148, 562.
7. *P. concavo-rugulosum* Abe. .....FAT 672, 744.

(2. All of the strains were slightly or perfectly extracted.

The character of many species or vareities, in producing precipitates at certain pH's, is useful in the separation of species (or varieties), but not in the separation of series, subsections or sections.

The specific characteristics of coloring matter as extracted with various solvents are useful in the separation of species (or varieties), but not in the separation of series, subsections, or sections.

We should note here, for use in future pigment studies, that the specific characteristics of coloring matter extracted at pH 2 or 7 or 9 with various solvents, are suggestive of the production of acid, neutral or alkaline substances.

The color-changes of the broth with changes in pH, observed in almost all the strains, are useful in the detection of general color changes, and helpful in the separation of species.

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V. THE pH, ACID PRODUCTION AND WEIGHT OF MYCELIA IN SURFACE CULTURE

Many studies on acid production by the *Penicillia* have been made by previous investigators. The following acid, produced by many *Penicillia*, were described: carolic acid, carlosic acid, carolinic acid, carlic acide, citric acid, gluconic acid, mycophenolic acid, phenolic acid, 3, 5-dihydroxypthalic acid, oxalic acid, penicillic acid, puberulic acid, emodic acid, ω-hydroxyemodin, 6-hydroxy–2-methylbenzonic acid, spiculisporic acid, stiptitatic acid, kojic acid, luteic acid, minioluteic acid, terrestric acid, ramigenic acid, verticillic acid, ellagic acid and gentisic acid.

In Japan, Sakaguchi[1] (1930) described the production of oxalic, citric and gluconic acid by *Citromyces*, and studies on acid-proudction (gluconic acid, fumaric acid, oxalic acid, citric acid, kojic acid, etc.) by the *Aspergillus niger* group, *Asp. oryzae*, etc. have been reported by many investigators.

Recently Simonart and Godin[2] (1951) described the formation of 2-ketogluconic acid and glucuronic acid by *Penicillium brevi-compactum*; Hockenhull, Wilkin and Winder[3] (1951) described the production of ketoglutarate by *Penicillium chrysogenum*; Godin[4] (1953) described the formation of gluconic, glucuronic, 2-ketogluconic, citric, malic, α-keto-glutaric, succinic, and fumaric acids, by submerged cultures of *Penicillium brevi-compactum*; Birkinshaw, Raistrick and Ross[5] (1952) described the molecular constitution of mycophenolic acid produced by *Penicillium brevi-compactum*; and Birkinshaw, Raistrick, Ross and Stickings[6] (1952) reported cyclopolic acid and cyclopaldic acids as metabolic products of *Penicillium cyclopium*; Raistrick and Ross[7] (1952) reported dihydrogladiolic acid as a metabolic product of *Penicillium gladioli*; and Isono[8] (1954) reported the production of homogentisic acid by a mutant strains induced from *P. chrysogenum* Thom Q 176.

In this study the author has investigated the pH, acid production and weight of dry mycelia of all strains listed in the systematic classification; strains were grown in surface culture on Czapek solution.

Experimental Method

Strains:

All strains of *Penicillium* listed in the systematic mophological classification.

Culture medium:

Czapek solution, previously described.

Conical flasks volume 300 ml, each containing 120 ml of Czapek solution, were plugged with cotton, sterilized at 120°C for 15 minutes, inoculated with one loopful of spores of each strain, then incubated for 7 days on Czapek agar. The flasks were incubated in the dark at 25°C for 25 to 28 days.

Determination of pH:

The culture filtrate was tested with a Beckman pH-meter.

Determination of acidity:

The acidity was determined by titration of 10 ml of culture filtrate with N/10 NaOH, a phenolphthalene indicator being used.

Determination of the weight of dry mycelia:

The mycelia obtained by filtration were dried in a desiccator with concentrated H_2SO_4 for 5 to 7 days at room temperature, and the weighed.

Results and Discussion

The pH, acidity (N-NaOH ml per 100 ml broth) and mycelial weigh (obtained from 120 ml broth) are shown in Table B-1 to 5.

The pH of the broth of almost all strains of the Monoverticillata was slightly or strongly acid, that of strains in the Divaricata subsection was generally acid or slightly alkaline, that of strains in the Velutina subsection was generally alkaline but sometimes acid, that of strains in the Fasciculata was alkaline or weakly acid, and that of strains in the Biverticillata-Symmetrica was weakly or rather strongly acid.

The strains of species or varieties which required over 2 ml of N-NaOH per 100 ml of broth from surface cultures, were as follows.

1) Monoverticillata.	Strain No.	N-NaOH ml.
1. *P. purpurrescens* (Sopp) Raper, Thom and Fennell	FAT 732	3.472
2. *P. frequentans* Westling	FAT 627	3.038
	FAT 1032	2.858
3. *P. citreo-viride* Biourge var. *aeneum* Abe.	FAT 124	3.645
4. *P. trzebinskii* Zaleski	FAT 252	2.163
	FAT 631	2.103
5. *P. trzebinskii* Zaleski var. *magnum* Sakaguchi and Abe	FAT 24	5.863
6. *P. trzebinskianum* Abe	FAT 728	4.059
7. *P. aurantio-violaceum* Biourge	FAT 561	4.944

8. *P. implicatum* Biourge	FAT 1128	3.569
9. *P. decumbens* Biourge	FAT 708	3.814
2) Divaricata subsection		
10. *P. janthinellum* Biourge	FAT 217	2.214
	FAT 1101	2.575
11. *P. simplicissimum* (Oud) Thom	FAT 768	4.068
12. *P. piscarium* Westling	FAT 905	7.828
13. *P. echinulo-nalgiovensis* Abe	FAT 884	7.622
14. *P. canescens* Sopp	FAT 832	3.554
3) Velutina subsection	None	
4) Fasciculata subsection		
15. *P. viridicatum* Westling	FAT 818	2.266
5) Biverticillata Symmetrica		
16. *P. herquei* Bainier and Sartory	FAT 1313	2.575

The substance responsible for the strong acidity of the broth of these strains are presumed to be the various acids mentioned in previous reports, but the exact determination of these substances was not pursued in this study.

Since this character was found to be characteristic in each strain, it is not useful for the classification of the *Penicillia*, but it is somewhat useful in the separation of strains.

The discovery of a few strains which showed strong acid-production is noteworthy.

The weight of the dry mycelia of each strain shows a correlation with its degree of growth, and the data showed that it is characteristic of individual strains. According, this character is not useful for classification of the *Penicillia*, but it is somewhat useful in the separation of species.

The various pigments and related substances contained in these dry mycelia were investigated by paper chromatography and other methods, with the cooperation of Prof. Shoji Shibata, University of Tokyo. The results were interesting and some pigments, presumed to be newly discovered were found as the products of a few strains. The author will to describe these data in future reports.

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VI. COLOR-REACTION WITH FERRIC CHLORIDE

Kojic acid, which gives a red color reaction with ferric chloride, is a pyrone derivative isolated by Saito[1] in 1907 from steamed rice on which *Aspergillus oryzae*, had grown. Yabuta[2] (1916–1924) coined the name kojic acid and determined the correct structure to be 5-hydroxy-2-hydroxylmethyl -pyrone.

This acid was been found to be accompanied by gluconic, citric and oxalic acids in cultures of a strain of *Aspergillus oryzae*, by Sakaguchi[3] in 1931.

It is a specific fermentation product which had been believed formerly to be produced from various kinds of carbon sources exclusively by *Aspergillus flavus-oryzae* and related species; one exception, *Penicillium dalae*, was reported by Birkinshaw[4] et al, 1931. Takahashi and Asahi[5] (1933, 1936) and Sakaguchi, Asai and Ikeda[6] (1944) reported that kojic acid was produced from mannitol and fructose by acetic acid bacteria, the acetic acid bacterium, *Gluconobacter liquefaciens*, produced to homologous oxidation product of kojic acid, commeric acid, from galactose, that fructose was decomposed to glycerine aldehyde and dioxyacetone by *Gluconobacter*, and that the dioxyacetone was oxidized to an unknown substance other than kojic acid which has a color-reaction with ferric chloride.

Ikeda[7] (1952) reported that the unknown substance was Hans von Euler's "Reductone"-like compound[8] which has an important relation to the metabolism of kojic acid formation, and *Gluconobactor roseus* Asai was reported to produce 2-ketogluconic acid and tartronic acid from glucose and glucosone; 2-ketogluconic acid, rubiginol and an unknown substance which gives a color-reaction with ferric chloride were prrduced from fructose, and dioxyacetone, reductone were produced from glycerine by oxidation.

Bousfield[9] et al (1947) reported that acetic acid bacteria produced an unknown substance of strong reducing power through the exidation of dioxy-

acetone from glycerine. Kondo and Wada[10] (1949) reported that *Gluconobactor* produced kojic acid, dioxyacetone and oxypyruvic acid from sorbose.

Aida, Kogima and Asai[11] (1954) and Aida[12] (1954) found three substances which gave reddish violet color reoctions with ferric chloride formed in the metabolic products of glucose by *Gluconoacetobactor liquefaciens*; one of them was named rubiginol and was assigned the strcture 3, 5-dihydroxyl, 1-4-pyrone.

According to Foster[13] (1949), rough qualitative reactions with $FeCl_3$ gave a blue or violet color with phenolic acids, a green color with citromycetine, a brown color with citrinin, a yellow color with lactic acid or malic acid, and a deep reddish color with kojic acid.

By adding single drops of 1 to 10% aqueous ferric chloride to a 10 ml sample the ferric chloride color-reaction and the substances responsible for it were determined by Backen[14] in 1955: kojic acid, which gave a blood red color, was produces by *Asp. flavus*, *Asp. oryzae* and *Asp. tamarii*; Citromycetin, which gave greenish black at first, then dark brown amorphous precipitates, was produced by *P. glabrum* and *P. pfefferianum*; citrine, which gave heavy buff precipitates at first, soluble in an iodine solution, was produced by *P. citrinum*, *P. impilcatum*, and others; and unknown substance which gave transient green at first, and finally permanent green, was produced by certain strains of *Penicillium italicum*; spinulosin, which gave deep brown (a purple layer if the culture is shaken with chloroform), was produced by *P. spinulosum*; methyl salicylic acid and gentisic acid, which gave a deep blue color, were produced by *P. griseo-fulvum*; mycophenolic acid, the C_{10} acid, which gave violet or shades of crimson or both, was produced by *P. brevi-compactum*; acids of the carolic acid type which gave orange or red colors, were produced by *P. charlesii*, *P. terrestre* and *P. cinerascens*; gentisyl alcohol, which gave a blue "flash" color, was produced by *P. patulum* Bainier; and fulvic acid, which gave a deep green color, was produced by *P. brefeldianum*.

Accordingly, the author investigated the color-reaction with ferric chloride of all the species, varieties and mutants of *Penicillium* described above, we observed that many strains produced color-reactive substance which gave violet purple, purple, red, scarlet, pink, orange, brown, blackish brown, citrine, green, bluish green, and pale citrine colors, in the upper layer and reddish or some similar colors in the lower layer. The author also found by paper chromatography that strain FAT 740 of *Penicillium expansum* (Link) Thom produced kojic acid.

Experimental Method

Strain:

One or two strains of each species, variety or mutant of *Penicillium* listed in the systematic morphological classification.

Culture:

Conical flasks volume 200 ml, each containing 120 ml of Czapek solution were plugged with cotton, sterilized at 120°C for 15 minutes, inoculated with one loopful of spores of each strain to be tested, then incubated for 7 days on Czapek agar. The flasks were incubated in the dark at 25°C for the 25 to 28 days.

Determination of the color reaction:

The culture fitrate was adjusted to pH 2 with concentrated HCl. 10 ml of each filtrate were poured into a 100 ml separation funnel, 2 ml ether added, the sample was shaken and separated, and then the same procedure was repeated. The total of 4 ml of ether were extracted twice with 2 ml distilled water.

One half volume was used for the determination of the reducing substance; the other half was used for the color-reaction with ferric chloride. The ferric chloride reaction was obtained by adding one or two drops of 1% aqueous ferric chloride to the above described solution, the colors examined, and the responsible substances were determined on this basis.

Results and Discussion

The various color reactions with ferric chloride and their degrees or shades are shown in Table B–1 to 5.

Strains were grouped according to color or shades, as shown. The color reaction is not specific for species or varieties but a character of individual strains. This was observed in the following species: *P. janthinellum* Biourge, *P. echinulo-nalgiovens* Abe, *P. citrinum* Thom, *P. roqueforti* Thom, *P. casei* Staub, *P. palitans* Westling, *P. expansum* (Link) Thom, *P. crustosum* Thom, *P. varians* Smith, *P. herquei* Bainier and Sartory, *P. paraherquei* Abe.

The substances responsible for color reactions may be known from the data described by Bracken[14] (1955), Foster[13] (1949) and others, but they were not determined exactly, except for strain FAT 740 of *Penicillium expansum* (Link) Thom, which was found by paper chromatography to produced kojic acid.

The author will be described the determination of the others in the future.

A. The colors or shades of substances extracted with ethyl ether.

Color or shade	Species or Varieties	Strain No.
1. Violet Purple	*P. urticae* Bainier	FAT 1314, 1315
2. Purple Red	*P. brunneo-stoloniferum* Abe	FAT 1132
3. Scarlet	*P. adametzioides* Abe	FAT 1301, 1302
	P. puberulum Bainier	FAT 1304, 1262
4. Pink	*P. roqueforti* Thom	FAT 1253
	P. varians Smith	FAT 1209

5. Pale Pink	*P. roqueforti* Thom var. *punctatum* Abe	FAT 314, 315
	P. casei Staub	FAT 817
	P. palitans Westling	FAT 985
	P. aurantio-virens Biourge	FAT 887
	P. parapherquei Abe	FAT 824
	P. purpurogenum Stoll var. *rubri-sclerotium* Thom	FAT 1210, 325
6. Orange	*P. trzebinskii* Zaleski	FAT 252, 631
	P. chermisinum Biourge	FAT 1287
	P. crustosum Thom	FAT 703
7. Pale Brown	*P. cinnamopurpureum* Abe	FAT 362, 363
	P. ochraceum Thom	FAT 766
	P. rugulosum Thom	FAT 322, 375
8. Brown	*P. stoloniferum* Thom	FAT 815, 709
	P. viridi-cyclopium Abe	FAT 843, 998
	P. expansum (Link) Thom	FAT 740
	P. clavigerum Demelius	FAT 1161
	P. purpurogenum Stoll var. *rubri-sclerotium* Thom (Non-sclerotigenic type)	FAT 1148, 562
	P. herquei Bainier and Sartory	FAT 1313
9. Balckish Brown	*P. viridicatum* Westling	FAT 818, 1273
	P. cyclopium Westling	FAT 840
10. Citrine	*P. fellutanum* Biourge var. *nigro-castaneum* Abe	EAT 623, 624
	P. janthinellum Biourge	FAT 1097
11. Pale Green	*P. trzebinskianum* Abe	FAT 1138, 728
	P. implicatum Biourge	FAT 1218, 807
	P. multicolor G.-M. and P.	FAT 1208
	P. sublateritium Biourge	FAT 328, 367
	P. steckii Zaleski	FAT 715
	P. echinulo-nalgiovens Abe	EAT 884
	P. aurantio-virens Biourge	FAT 1226
12. Green	*P. cyclopium* Westling	FAT 1052
	P. aurantio-virens Biourge	FAT 334
13. Bluish Groen (Strongly)	*P. multicolor* G.-M. and P.	FAT 1051
14. Pale Citrine in upper layer and Reddish in lower layer	*P. citrinum* Thom	FAT 600
	P. steckii Zaleski	FAT 509
15. Yellow Precipitate	*P. tomii* Maire	FAT 388

B. The colors or shades of waste broth after extraction with ethyl ether.

1) Color or shades not similar to the color reaction of the substance extracted by ethyl ether.

1. *P. adametzioides* Abe .....Xanthine Orange....FAT 1301, 1302
2. *P. palitans* Westling .....Pale Brown .....FAT 985
3. *P. urticae* Bainier .....Brown .....FAT 1314, 1315

2) The substances were completly extracted by ethyl ether, and no color reaction was seen in the waste broth after extraction.

1. *P. sublateritium* Biourge.. .....FAT 328, 367
2. *P. chermisinum* Biourge .....FAT 1287
3. *P. fellutanum* Biourge var. *nigro-castaneum* Abe ..FAT 623, 624
4. *P. stoloniferum* Thom .....FAT 815, 709
5. *P. varians* Smith .....FAT 1209
6. *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom.FAT 1201
7. *P. rugulosum* Thom .....FAT 322, 375

3) The substances of color reactions were not extracted by ethyl ether.

1. *P. citrinum* Thom .....Pale Green.....FAT 513
2. *P. corylophilum* Dierckx .....Citrine .....FAT 706, 595
3. *P. chrysogenum* Thom .....Pale Citrime.....FAT 854
4. *P. notatum* Westling .....Citrine .....FAT 577
5. *P. martensii* Biourge .....Pale Brown .....FAT 1201

4) The color reaction was not seen after extraction with ethyl ether, but a white muddy precipitate was found in the waste broth in combination with ferric chloride.

1. *P. varians* Smith.....FAT 379
2. *P. rubrum* Stoll .....FAT 1145
3. *P. diversum* Raper and Fennell.....FAT 1294

Color reactions with ferric chloride are not useful for the separation of species, but they are somewhat useful in the separation of stains.

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VII. REDUCING SUBSTANCES

As mentioned in the section on the ferric-chloride reaction, many investigators have described reducing substances of metabolic intermediates in various kinds of fermentation. By ether extraction of the broth, reductone, pyruvate, dioxy-acetone, acetoaldehyde, diacetyl, and oxypyruvic acid, are found presumably the reducing substances of intermediates of metabolism.

Twelve species or varieties were found, by ether extraction and incubation with Fehling solution for 24 hours at 25°C to produce reducing substances.

Eight species and varieties were found to produce reducing substances after being boiled for three minutes following 24 hours of incubation at 25°C with Fehling solution.

Experimental Method

As described in the article on the color reaction with ferric-chloride, about 2 ml of ether-extract was poured into a 10×100 mm. test tube, 1 ml water was added, and the ether was evaporated in a water both at 60° to

70°C; 0.5 ml Fehling-alkali solution and 4.5 ml water were added, and the mixture was kept at 25°C for 24 hours. It was then examined to see whether or not precipitates were formed.

After that the mixture was boiled for three minutes in a water bath and the appearance of the precipitates was again examined.

Results and Discussion

The characters of various strains of *Penicillium* are shown in Table B–1 to 5. The following species and varieties produced reducing substances as metablic products from surface cultures on sucrose Czapek solution at 25°C.

A) CuO precipitated after 24 hours incubation at 25°C.

1. *P. multicolor* G.-M. and P. .....FAT 1051.
2. *P. adametzioides* Abe. .....FAT 1301, 1302.
3. *P. capsulatum* Raper and Fennell. .....FAT 564
4. *P. ochro-chloron* Biourge.....FAT 906.
5. *P. citrinum* Thom. .....FAT 1131.
6. *P. chrysogenum* Thom.....FAT 1020, 914, 506.
7. *P. chrysogenum* Thom mut. *fulvescens* Takashima, Arima and Abe. .....FAT 515.
8. *P. meleagrinum* Biourge.....FAT 1222.
9. *P. notatum* Westling.....FAT 579.
10. *P. cyaneo-fulvum* Biourge. .....FAT 699.
11. *P. duclauxi* Delacroix. .....FAT 1293.
12. *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom. (Non-sclerotigenic type) .....FAT 1148, 562.

B) CuO precipitated after three minutes boiling following 24 hours incubation at 25°C.

1. *P. fusco-flavum* Abe.....FAT 1081.
2. *P. ochro-chloron* Biourge.....FAT 828.
3. *P. meleagrinum* Biourge var. *viridi-flavum* Abe. .....FAT 803.
4. *P. palitans* Westling.....FAT 838.
5. *P. palitans* Westling var. *echinoconidium* Abe. .....FAT 1019.
6. *P. cyclopium* Westling.....FAT 840.
7. *P. purpurogenum* Stoll. .....FAT 76.
8. *P. rubrum* Stoll. .....FAT 1154.

The constituents of the reducing substances were not determined, but the intermediates of metabolism are assumed to be reductone, pyruvate, dioxy-acetone, acetoaldehyde, diacetyl, oxy-pyruvic acid, etc. The exact determination of these substance is an interesting problem to be examined in future study.

VIII. FLUORESCENT SUBSTANCES

The production of flavin by micro-organisms was first reported by Gulliermond[1] (1935), using *Eremothecium ashbyii* Gulliermond, and later by Saito and Takada[2] (1942, 1943). Studies on the production of flavin by *Clostridium butylicum* Przmowski were reported by Mirimanoff and Rafey[3] (1938), and studies of *Clostridium aceto-butylicum* and yeast were reported by Yamasaki[4] (1948–1939).

Flavins were produced by *Aspergillus batatae* Saito, and by *Aspergillus oryzae*, as reported by Tachibana[5] (1939). Kihara, Murooka and Sakaguchi[6] (1948) found fluorescent substances in koji extract solutions produced by 187 strains of *Aspergillus oryzae* and in extracts of *Aspergillus batatae* and *P. glaucum*. The colors, yellow, blue, blue-green, purplish-blue, bluish-white, and the intensity of color, differed with the strains; the yellow fluorescent substance was flavin.

Kaneko, Sakaguchi and Kihara[7] (1949) examined 255 species and strains of *Aspergillus*, as well as *P. glaucum brudny* and *P. luteum Zukal*, for the production of fluorescent substances; yellow, purplish-blue, green (combined yellow and blue) colors were found in koji extract solutions, and some cultures which produced large amouts of riboflavin were found.

Kaneko[8] (1955) recently reported that a putulin-like fluorescent substance of bluish white was purified from the broth of *Aspergillus oryzae* (K.B.).

Felsher[9] (1949) reported a green fluorescent material in hairs infected by Microsporon in *Tinea capitis* and this could be extracted with hot water or with 2N-NaBr; the aqueous extract was green at pH 5.5 and blue at pH 8; the BaBr extract was green at pH 9, blue green in the pH range from 8 to 2.5, and blue at pH 2.

Hatta, Aogama and Tanji[10] (1950) found that several fungi and bacteria produce pyrogens of ultra violet blue fluorescence. *Mactsporium*, *Micrococcus*, *Salmonella typhi* and *S. paratyphi* B. were used.

Iizuka[11] (1952) isolated *Aspergillus mangini* from spoiled food, and it produced a yellow-green fluorescent substance in the medium. Crystals (melting point 152°C) believed to be auroglaucin were oblained from the mycelial mat of this mold. Totter and Moseley[12] (1953) reported the production of fluorescin by *Pseudomonas aeriginosa*, and Poe and Weite[13] (1953) descbed the formation of a fluorescent green pigment by six strains of *Pseudomonas*.

In *Penicillium*, however, the production of fluorescent substances had not been found except in *P. glaucum* Brudny, by Kaneko, Sakaguchi and Kihara (1948 and 1949).

Therefore the author investigated all species, varieties and mutants of *Penicillium* described previously, and has found that many strains produce fluorescent substance of yellow, blue, purple, and blue-purple colors.

Experimental Method

Strains: One or two strains of each species, variety, and mutant of *Penicillium* by listed in the systematic morphological classification.

Culture: Conidial flasks volume 200 ml, each containing 120 ml of Czapek solution, were plugged with cotton, sterilized at 120 C fop 15 minutes, and inoculated with one loopful of spores from cultures which had been incubated for 7 days on Czapek agar. The flasks were incubated in the dark at 25°C for 25 to 28 days.

Determination of the fluorescent substances: The cultur filtrates were adjusted to pH 2, 7 and 9 by concentrated HCl or NaOH. Twenty ml of each filtrate was poured into a 15×170 mm. test tube. The color and amount of the fluorescent substances were determined in a dark room by ultraviolet light.

Results and Discussion

The colors and amounts of fluorescent substances in all strains are shown in Tables B–1 to 5. The amount produced was described as follows: trace produced, ±; small amount produced, +; considerable amount produced, ++; large amount produced, +++; and abundantly produced, ++++.

Similar results were obtained at all the pH's examined. In forty-nine species and varieties, fluorescent substances were produced. By their colors and amounts of fluorescent substances, species and varieties were separated as follows:

1) Yellow color trace produced.
   1. *P. cinnamopurpureum* Abe. .....FAT 362, 363.
   2. *P. purpurrescens* (Sopp) Raper, Thom and Fennell. .....FAT 732.
   3. *P. citreo-viride* Biourge var. aeneum Abe. .....FAT 124.
   4. *P. echinulo-nalgiovense* Abe. .....FAT 884.
   5. *P. claviforme* Bainier. .....FAT 554.
   6. *P. corymbiferum* Westling. .....FAT 606.

2) Yellow color small amount produced.
   1. *P. implicatum* Biourge.....FAT 1218.
   2. *P. multicolor* G.-M. and P.....FAT 1208.
   3. *P. roseo-purpureum* Dierckx. .....FAT 1288.
   4. *P. olivino-viride* Biourge.....FAT 636.
   5. *P. puberulum* Bainier. .....FAT 1304.
   6. *P. aurantio-virens* Biourge. .....FAT 887.
   7. *P. claviforme* Bainier. .....FAT 739.
   8. *P. aculeatum* Raper and Fennell var. *apiculatum* Abe. .....FAT 1152, 1189.
   9. *P. concavo-rugulosum* Abe. .....FAT 672.

10. *P. diversum* var. *aurenm* Reper and Fennell. ..FAT 1295.
11. *P. herquei* Bainier and Sartory. .....FAT 954.

3) Yellow color considerable amount or large amount produced.
1. *P. sclerotiorum* van Beyma. .....FAT 1181.
2. *P. multicolor* G.-M. and P.....FAT 1051.
3. *P. melinii* Thom. .....FAT 581.
4. *P. brunneo-stoloniferum* Abe.....FAT 1132.
5. *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom. .....FAT 562.
6. *P. concavo-rugulosum* Abe. .....FAT 744.
7. *P. varians* Smith. .....FAT 1209.
8. *P. citrinum* Thom.....FAT 1131.

4) Yellow color abundantly produced.
1. *P. thomii* Maire. .....FAT 388.
2. *P. brevi-compactum* Dierckx. .....FAT 1285.
3. *P. stoloniferum* Thom. .....FAT 815, 709.

*-1) Blue or pale blue color small amount produced.
1. *P. spinulosum* Thom. .....FAT 688.
2. *P. aurantio-violaceum* Biourge. .....FAT 1008.
3. *P. oxalicum* Currie and Thom. .....FAT 258.
4. *P. roqueforti* Thom. .....FAT 733.
5. *P. casei* Staub var. *compactum* Abe. .....FAT 1276.
6. *P. paxilli* Bainier. .....FAT 1286.
7. *P. puberulum* Bainier. .....FAT 1262.
8. *P. italicum* Wehmer.....FAT 744.
9. *P. verruculosum* Peyronel. .....FAT 665.
10. *P. tardum* Thom. .....FAT 169, 1183.

*-2) Blue or light blue color considerable amount or large amount produced
1. *P. implicatum* Biourge. .....FAT 807.
2. *P. decumbens* Thom var. *atro-virens* Abe.....FAT 1140.
3. *P. chrysogenum* Thom.....FAT 854.
4. *P. wortmanni* Klocker. .....FAT 364.
5. *P. rubrum* Stoll. .....FAT 1154.
6. *P. aculeatum* Raper and Fennell. .....FAT 810.
7. *P. paraherquei* Abe. .....FAT 964.
8. *P. estinogenum* Komatu and Abe.....FAT 1195, 1196.

*-3) Blue color abundantly produced.
1. *P. trzebinskianum* Abe.....FAT 1138.
2. *P. restrictum* Gilman and Abbott. .....FAT 779.
3. *P. steckii* Zaleski. .....FAT 715.

**-1) Blue-purple color abundantly produced.
1. *P. paraherquei* Abe. .....FAT 834.

**-2) Blue-purple considerable amount produced.
1. *P. varians* Smith. .....FAT 379.

***-1) Purple color small amount produced.
1. *P. citreo-virens* Abe. .....FAT 319.
2. *P. albicans* Bainier. .....FAT 1316.

***-2) Purple color considerable amount or large amount produced.
1. *P. frequentans* Westling. .....FAT 627.
2. *P. decumbens* Thom. .....FAT 604.
3. *P.citreo-virens* Abe. .....FAT 320.
4. *P. pseudo-casei* Abe. ....(Near violet shades)—FAT 1166.
5. *P. aurantio-virens* Biourge.....FAT 1226, 334.
6. *P. rugulosum* Thom.....FAT 322, 375.

In some species, such as *P. implicatum* Biourge, *P. puberulum* Bainer, *P. aurantio-virens* Biourge, *P. varians* Smith, and *P. herquei* Bainier and Sartory, different fluourescent substances were produced from strains to strain. *P. concavo-rugulosum* Abe produced a yellow color, and yet *P. rugulosum* Thom produced a blue-purple substance. *P. aculeatum* Raper and Fennell produced a blue color, and yet *P. aculeatum* Raper and Fennell var. *apiculatum* Abe produced a yellow substance. In the following species or varieties, some strains produced fluorescent substances and others did not: *P. frequentans* Westling, *P. spinulosum* Thom, *P. aurantio-violaceum* Biourge, *P. trzebinskianum* Abe, *P. decumbens* Thom, *P. decumbens* Thom var. *atro-virens* Abe, *P. roseo-purpureum* Dierckx, *P. melinii* Thom, *P. citrinum* Thom, *P. steckii* Zaleski, *P. chrysogenum* Thom, *P. oxalicum* Currie and Thom, *P. roqueforti* Thom, *P. pseudo*-casei Abe, *P. olivino-viride* Biourge, *P. verruculosum* Peyronel, *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom, *P. rubrum* Stoll and *P. herquei* Bainier and Sartory. Therefore, the property of producing fluorescent substances appears to be characteristic of individual strains, and is not suitable as a basis for the separation of species and varieties.

But the discovery of the production of fluorescent substances in many strains of the genus *Penicillium* is interesting in itself.

The determination of the substances respensible for the fluorescence will be described in future reports.

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IX. PECTIN CLARIFICATION ACTIVITY

Davison and Willaman[1] (1927) made a detailed study of the occurrence of protopectinase in fungi. This enzyme is produced by *Botytis cinerea* and *Rhizopus tritici*. In addition, *Sclerotinia*, the plum-rotting fungus, and *Fusarium chromyophthorn* were reported to form this enzyme by Sideris[2] (1924).

In addition the enzyme has been reported in numerous species of *Rhizopus*, by Harter and Weimer[3] (1921) and in various *Penicillia*, including *P. erhlich*, by Ehrlich[4] (1932).

Kertesz[5] (1936), Jansen and MacDonnell[6] (1945), Gaumann and Bohni[7] (1947), Ehrlich[8] (1937), Lineqeaver and Ballou[9] (1945), Waksman and Allen[10] (1933), Proskuriakov and Ossipov[11] (1939), Menon[12] (1934) and Harter and Wiemer[3] (1921–1923) reported on the pectinase enzyme complex and the pectin enzymes formed by *Asp. niger* and *Asp. oryzae*, *Fusarium* sp., *F. fructigenum*, *Monilia fructigena*, *Phytophthora erythroseptica*, *Glocosporium fructigenum*, *Rhizopus nigricans*, *R. artocarpi*, *R. chinensis*, *R. microsporus*, *Mucor* sp., *Penicillium* sp., etc.

Pfaff[13] (1947) published detailed studies of the enzyme in *Penicillium chrysogenum* Thom. In Japan, Iwasaki[14] (1951, '52, '54) reported on the pectic enzyme and the estimation of pectin and pectolic acid, as well as the activity of *P. oxalicum* Currie and Thom var. *pectinovorum* Iwasaki; Takagawa[15] (1939) reported on the decomposition of pectin by fungi (*P. fusco-*

glaucum, *P. fluitans*, *P. jenseni*, *P. vinaceum*, *P. humicola*, *P. lividum*, *P. spinulosum*, *P. glabrosporum*, *P. luteo-viride* var., *P. roseo-purpureum*, *P. baiiolum*, *P. notatum*, *P. raciborskii* var., *P. funiculosum*, *P. purpurogenum*, *P. luteum*, *P. glaucum*, *Aspergillus*, *Mucor*, *Rhizopus*, *Oidium*, *Sclerotium*, etc. a total of 94 strains); Ozawa et al[16] (1948 to 1954) reported on the microbiological decomposition of pectin by *P. expansum*, butyric acid bacteria, etc. and the polygalacturonase of *P. expansum*.

Fujii et al[17-19] (1952–1954) reported the production of pectic enzyme in submerged cultures of *Asp. niger* and Furuichi[20], Okamoto (1954) reported yeast pectic enzymes.

Asai and Saito[21] (1952) reported the adaptive formation of pectin enzymes by *Asp. niger*, while Saito, Minoda and Marumo[22] (1954) and Saito[23] (1954, '55) reported the depolymeric polygalacturonase and pectin glycosidases of *Asp. niger* in detail.

The enzymic activities of numerous species of *Penicillium* given in the systematic morphological classification had not yet been published, however.

Therefore the pectin clarification activities of many species, varieties and mctants of *Penicillium* were investigated for the purpose of finding strains useful in industry.

Experimental Method

Strains:

One or two strains of each species of *Penicillium* in listed the systematic morphogical classification.

Culture:

Conical flasks of 100 ml, each containing 20 ml of Czapek–0.5% pectin solution (pectin, 5 gms.; sucrose, 25 gms.; $NaNO_3$, 3.0 gms.; K_2HPO_4, 1.0 gm.; $MgSO_4 \cdot 7H_2O$, 0.5 gm.; KCl, 0.5 gm; $FeSO_4 \cdot 7H_2O$, 0.01 gm.; distilled water, 1 liter; pH adjusted to 5.5) were plugged with cotton, sterilized at 120°C for 15 minutes and inoculated with one loopful of spores of cultures which had been incubated for 7 days on Czapek agar.

The flasks were incubated in the dark at 25°C for 10 to 20 days.

Determination of enzyme activity:

The culture filtrate was adjusted to pH 5.5 and mixed with enzyme solution, 0.5 ml; 1% pectin solution, 2.0 ml, Maclavine buffer solution (pH 5.5), 2.5 ml and toluol, 0.1 ml, in an 8×120 mm. test tube which was plugged with cotton and sterilized. After incubation in the dark at 30°C for 24 hours, 0.1 ml of 1 mol $CaCl_2$ solution was added. In the test tube containing pectin decomposing enzymes, jelly-like or small segmented substances, colorless or weakly yellowish, (Ca-salts of pectinic acid or partial hydrolyzates of pectin) precipitated and the upper layer was clarified. The pectin clarification activity was measured by estimating the amount of precipitate and the degree of clarification of the upper solution.

Aspergillus niger No. 55 received in 1954 from Prof. K. Sakaguchi, University of Tokyo, originally obtained from Prof. C. Furusaka, University of Tohoku, was used as the control strain in this study.

Results and Discussion

The pectin clarification activities of *Penicillium* are shown in Table B–1 to 5. *Aspergillus niger* No. 55, the control, formed precipitates about 7 mm. in depth and clarified the upper solution. The following seven strains were found to be strongly active: *P. adametzioides* Abe, FAT 1301, 1302; *P. terlikowski* Zaleski, FAT 776; *P. oxalicum* Currie and Thom, FAT 258; *P. digitatum* Saccardo var. *latum* Abe, FAT 605; *P. italicum* Wehmer, FAT 774; and *P. paraherquei* Abe, FAT 824.

Among them, the first has particularly strong activity and is already giving excellent results in the apple wine industry in Japan.

About 40 additional strains were found to be moderately active.

Though the nature of the pectin-methyl esterase and of the pectin polygalacturonase were not determined (there is probably a complex action of pectic enzymes), this information may be adequate for the purpose of industrial use, such as wine or juice making.

As seen in Table B–1 to 5, some strains exhibit much stronger enzymatic activity than the control, *Asp. niger* No. 55, but since the properties of the pectic enzymes produced by *Aspergillus* may be somewhat different from those of *Penicillium*, an exact evaluation of their utility cannot be made.

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SUMMARY

Since 1949 the author has received about 3500 samples sent from Universities and Laboratories in Japan. They were collected of soils of different places and of other materials (fruits, vegetables, corn, flowers, leaves, refuse, decaying matter, etc.).

About 10,000 strains were isolated from the samples, and these about 3000 strains were selected on the basis of colonial and microscopic characters.

By detailed observation and continuous-monospore culture 1,200 strains were further selected. We also examined about 150 strains of *Citromyces*

and *Penicillium*, previously studied by Sakaguchi (1930) the collection of *Penicillia* at University of Tokyo, *Penicillia* sent by many investigators in Japan as unknown species, and 13 strains sent by Drs. K. B. Raper and D. I. Fennell, the University of Wisconsin, to Prof. K. Sakaguchi, the University of Tokyo, in 1952.

In addition, about 600 other strains (the collection of *Penicillia* at Universities and Laboratories in Japan) were carefully observed by current culture.

All of the 1950 strains currently described have been under observation for a period of at least three years, and some for more than five years.

In this report we have described only normal strains; we did not include the yeast, sterile, and irregular types having abnormal or undeterminable penicilli and colonies, or the genera *Gliocladium*, *Paecilomyces* and *Scopulariopsis*, which will be considered in other reports.

All of the strains studied were assigned to species or varieties chiefly on the basis of Raper, Thom and Fennell's classification (1949), but many differences were observed from previous reports.

A total 116 species and varieties were classified by morphological characters chiefly.

In the previous classification mostly morphological observations are used, but in this classification the following biochemical characters were also studied and used. And, then new clssification made of (See, 33–49 page).

A. Colony characteristics and microscopic characters.
   1. Penicillus.
   2. Peritheciea.
   3. Texture.
   4. Rate of growth.
   5. Depth of colony.
   6. Character of surface.
      a. Zonation.
      b. Color of mycelium.
      c. Furrow or Wrinkle and Plane or Smooth, etc.
      d. Steril overgrowth.
   7. Character of margin.
   8. Colony color and color change.
   9. Exudate.
   10. Colony reverse.
   11. Pigmentation of substratum.
   12. Conidial chain.
   13. Conidia.....Form.
   14. .....Size.
   15. .....Marking.
   16. Sterigmata. .....Usual number and arrangement.
   17. .....Diameter.
   18. .....Length.

19. .....Form or shape.
20. .....Marking.
21. Metulae .....Usual number and arrangement.
22. .....Apices dimension.
23. .....Diameter.
24. .....Length.
25. .....Marking.
26. Branches .....Usual number and arrangement.
27. .....Dimension of Apices.
28. .....Diameter.
29. .....Length.
30. .....Marking.
31. Conidiophore.....Origin or Ramigenous.
32. .....Foot cell.
33. .....Dimension of Apices.
34. .....Diameter.
35. .....Length.
36. .....Marking.

B. Biochemical Characteristics.

37. Rate of growth.....at 5°, 15°, 25°, 30°, 37°C.
38. Growth on Sakaguchi and Wang agar.
39. Antifungal or antibacterial activity.
    Staphylococcus aureus 209 P.
    Bacillus subtilis.
    Escherichia coli.
    Candida albicans Yu 1200.
    Mycobacterium 607.
    Saccharomyces cerevisiae.
    Aspergillus oryzae.
40. Color and color change of broth due to changes in pH.
41. Extraction of the pigments of broth with various solvents in acid, neutral and alkaline solution.
42. pH of broth, acidity, and weight of dried mycelia.
43. Color reaction with ferric chloride.
44. Reducing power.
45. Fluorescent substances.
46. Clarification activity (pectin).

Fourteen species, thirteen varieties and three mutantions of *Penicillium* described as new. They include:

1) One sclerotigenic species and one variety:

1. *Penicillium cinnamopurpureum* Abe produces monoverticillate pinicill and sclerotia that are surrounded by conspicuous envelopes of grayish

vinaceous or brown mycelium. It is assignable to the Monoverticillata, near *P. sclerotiorum* van Beyma.

2. *Penicillium thommi* Maire var. *flavescens* Abe produces monoverticillate penicilli that are embedded in masses of white hyphae and elliptical sclerotia. It is closely related to *P. thomii* Maire.

2) Thirteen non-ascosporic species, twelve varieties, and three mutations:

1. *Penicillium trzebinskianum* Abe produces monoverticillate penicilli and conidia with echinulate or verruculose walls. It is assignable to the Monoverticillata, near *P. trzebinskii* Zaleski.
2. *Penicillium trzebinskii* Zaleski var. *magnum* Sakaguchi and Abe produces monoverticillate penicilli and conidia that have echinulate or verruculose walls and larger elliptical form. It is closely related to *P. trzebinskii* Zaleski.
3. *Penicillium decumbens* Thom var. *atro-virens* Abe produces monoverticillate penicilli comparatively short conidiophores, and elliptical conidia; it usually produces blackish yellow green conidia. It is closely related to *P. decumbens* Thom.
4. *Penicillium fellutanum* Biourge var. *nigro-castaneum* Abe produces monoverticillate penicilli, a strongly brownish-red color in reverse, and blackish green conidia. It is closely related to *P. fellutanum* Biourge.
5. *Penicillium citreo-viride* Biourge var. *aeneum* Abe produces monoverticillate penicilli, pale yellow green conidia, and usually a brownish color in the central area in reverse. It is closely related to *P. citreo-viride* Biourge.
6. *Penicillium fusco-flavum* Abe is very restrictedly spreading, produces monoverticillate penicilli, and blackish yellow-green conidia that have conspicuously echinulate or verruculose walls and a long elliptical form.

   It is assignable to the Monoverticillata near *P. restrictum* Gilman and Abbott.
7. *Penicillium adametzioides* Abe produces monoverticillate penicilli and conidia that are elliptical and smooth walled or nearly so, some strains are also velvety in texture. It is assignable to the Monoverticillata near *P. adametzi* Zaleski.
8. *Penicillium lilacino-echinulatum* Abe produces monoverticillate penicilli, conidia that are globose with conspicuously verruculose or echinulate walls, of typically funiculose character, and pale grey green color; growth is restricted. It is assignable to a series typified by *P. adametzi* in Raper, Thom and Fennell's classification.
9. *Penicillium charlesii* Smith var. *rapidum* Abe produces monoverticillate penicilli borne on short branches from ascending hyphae, and dark yellowish green conidia, with smooth walls or nearly so; colonies are rather rapidly spreading.

   It is closely related to *P. charlesii* Smith.
10. *Penicillium echinulo-nalgiovense* Abe produces strongly divaricate and

asymmetrical penicilli, and conidia with echinulate or verruculose walls and ovate form. It is assignable to the Asymmetrica near *P. nalgiovensis* Laxa.

11. *Penicillium nigricans* Thom var. *sulfuratum* Abe produces asymmetrical and strongly divaricate penicilli. conidia with aculeate walls, and yellow color in the reverse becoming pink; colonies are rather rapidly spreading.

    It is closely related to *P. nigricans* Thom.

12. *Penicillium corylophiloides* Abe produces biverticillate and asymmetrical penicilli with branches seldom produced, conidia with smooth walls or nearly so and typically elliptical form, and also metulae of unequal length and rather long, usually in 4 to 8 terminal verticils. It is assignable to the Asymmetrica-Velutina near *P. corylophilum* Dierckx.
13. *Penicillium citreo-virens* Abe produces asymmetrical penicilli, rarely branched, bright yellow green conidia, and green color in the reverse most media. It is assignable to the Asymmetrica-Velutina near *P. citrinum* Thom.
14. *Penicillium chrysogenum* Thom mut. *fulvescens* Takashima, Arima and Abe produces asymmetrical penicilli and conidia of cinnammon color. This mutant was obtained from a normal green strain of *P. chrysogenum* Thom by ultra-violet irradiation.
15. *Penicillium meleagrinum* Biourge var. *viridi-flavum* Abe produces asymmetrial penicilli, and conida, mostly 2.1 to 3.0 μ in length and of elliptical form, quickly becoming dull green. It is closely related to *P. meleagrinum* Biourge.
16. *Penicillium digitatum* Saccardo var. *latum* Abe produce asymmetrical penicilli, and conidia with strongly cylindrical form, and a typical blue-green color, colonies are broadly spreading. It is closely related to *P. digitatum* Saccardo.
17. *Penicillium roqueforti* Thom var. *punctatum* Abe produces asymmetrical penicilli, conidiophores with typically punctate or smaller granular walls, and conidia with delicately echinulate or verruculose walls (protuberances more than 0.2 μ in length). It is closely related to *P. roqueforti* Thom.
18. *Penicillium casei* Staub. var. *compactum* Abe produce asymmetrical penicilli with cellular elements closely compact, conidia with spinulose walls, and conidiophores with larger granular walls. It is closely related to *P. casei* Staub.
19. *Penicillium pseudo-casei* Abe produces asymmetrical penicilli, typically elliptical conidia with smooth walls or nearly so conidiophores with larger granular walls, and also colorless or pale yellow reverse; colonies are rather rapidly spreading. It is assignable to the Asymmetrica-Velutina near *P. casei* Staub.
20. *Penicillium brunneo-stoloniferum* Abe produces asymmetrical penicilli

with cellular elements closely compact, and elliptical to subglobose conidia in bright brown colors. It is assignable to the Asymmetrica-Velutina near *P. stoloniferum* Thom.

21. *Penicillium palitans* Westling var. *echinoconidium* Abe produces asymmetric penicilli, typically fasciculate colonies, and conidia with conspicuously echinulate or verruculose walls, in typical yellow green colors.

It is assignable to the Asymmetrica-Fasciculata near *P. palitans Westling.*

22. *Penicillium viridi-cyclopium* Abe produces asymmetrical penicilli, fasciculate colonies, typical, quickly diffusing orange or brownish colors in the surrounding agar, and blue-green or typical yellow green conidia.

It is closely related to the Asymmetrica-Fasciculata near *P. viridicatum or P. cyclopium series* according to Raper, Thom and Fennell's classification.

23. *Penicillium claviforme* Bainier mut. *candicans* Abe ahd Ura produces asymmetrical penicilli and coremia, and colorless conidia. The mutant was obtained from a normal green strain of *P. claviforme* Bainier by ultra-violet irradiation.

24. *Penicillium claviforme* Bainier mut. *olivicolor* Abe and Ura produces asymmetrical penicilli and coremia, and conidia of olivish color.

The mutant was obtained from a normal green strain of *P. claviforme* Bainier by ultra violet irradiation.

25. *Penicillium aculeatum* Raper and Fennell var. *apiculatum* Abe produces symmetrical penicilli, lanceolate sterigmata, and conidia of typically ovate form with one end apiculate, having conspicuously echinulate or verruculose walls; colonies are rather rapidly spreading.

It is assignable to the Biverticillata-Symmetrica near *P. aculeatum* Raper and Fennell.

26. *Penicillium concavo-rugulosum* Abe produces symmetrical penicilli, lanceolate sterigmata, conidia strongely elliptical with walls smooth or nearly so (spines less than 0.1 μ) and orange, orange-brown or red-brown colors developing either in localized areas or throughout the reverse. It is assignable to the Biverticillata-Symmetrica, near *P. rugulosum* Thom.

27. *Penicillium paraherquei* Abe produces symmetrical penicilli, characteristically tapered or narrow sterigmata, and elliptical conidia, mostly 2.9 to 3.3 μ in length with slightly roughened walls; colonies are broadly spreading. It is assignable to the Biverticillata-Symmetrica near *P. herquei* Bainier and Sartory.

28. *Penicillium estinogenum* Komatu and Abe produces symmetrical penicilli, narrowly tapered sterigmata, elliptical or ovate conidia with typically granular or verruculose walls and metulae in loosely compact or somewhat divergent arrangement. It is assignable to the Biverticillata-Symmetrica, near *P. herquei* Bainier and Sartory.

The list of laboratory strains classified.

I. Monoverticillata.

A. Sclerotigenic species and variety.

1. *P. sclerotiorum* van Beyma. .....FAT 1181, (1335.)
2. *P. thomii Maire.* .....FAT 388.
3. *P. thomii Maire* var. *flavescens* Abe. FAT 340.
4. *P. cinnamopurpureum* Abe. .....FAT 362, 363.

B. Non-ascosporic species and varieties.

5. *P. purpurrescens* (Sopp) Raper, Thom and Fennell. .....FAT 13, 559, 732, 576, (782).
6. *P. spinulosum* Thom. .....FAT 571, 621, 14, 15, 1120, 668, 587, 639, 1137, (1340).
7. *P. lilacino-echinulatum* Abe. .....FAT 84.
8. *P. restrictum* Gilman and Abbott. FAT 779.
8. *P. fuscum* (Sopp) Raper, Thom and Fennell. .....FAT 1343.
10. *P. frequentans* Westling. .....FAT 103, 632, 627, 1029, 323, 1254, 1256, 1032, 826, 839, 570, 590, 1223, 12, 30, (1391, 1341, 1440, 1435, 1332, 1317).
11. *P. citreo-viride* Biourge. .....FAT 568, 1022, 1176, 1229, 967, 970, 959, 196, 567, 653, 960, 359, 360, 1023, 569, 326, (172, 179, 186, 223, 166, 196, 51, 53.)

Synonym: *P. toxicarium* Miyake .....(FAT 1269, 1345, 745)

12. *P. citreo-viride* Biourge var. *aeneum* Abe. .....FAT 124, 122, 123.
13. *P. vinaceum* Gilman and Abbott. FAT 1291.
14. *P. multicolor* G.—M. and P. .....FAT 637, 1208, 1051, 125, 934, 933, 1214, 1186, 929, 1216, 1230.
15. *P. roseo-purpureum* Diercex. .....FAT 780, 1288.
16. *P. terlikowskii* Zaleski. .....FAT 776, 1290.
17. *P. trzebinskii* Zaleski. .....FAT 252, 631.
18. *P. trzebinskii* Zaleski var. *magnum* Sakaguchi and Abe. ..FAT 24.
19. *P. trzebinskianum* Abe. .....FAT 1138, 728.
20. *P. fusco-flavum* Abe. .....FAT 1081.
21. *P. lividum* Westling. .....FAT 877, 626, 73, (1336).
22. *P. aurantio-violaceum* Biourge. ..FAT 1008, 121, 649, 74, 561, 601.
23. *P. chermisinum* Biourge. .....FAT 1287.
24. *P. phoeniceum* van Beyma. .....FAT 1292.
25. *P. implicatum* Biourge. .....FAT 825, 1218, 1220, 977, 137, 1299, 563, 640, 807, 936, 813, 829, (1324).
26. *P. sublateritium* Biourge. .....FAT 328, 367.
27. *P. adametzioides* Abe. .....FAT 1301, 1302.
28. *P. decumbens* Thom. .....FAT 588, 708, 602, 603, 604, 1071, (63, 66).

29. *P. decumbens* Thom var. *atro-virens* Abe. ..... FAT 329, 1140.
30. *P. fellutanum* Biourge. ..... FAT 767, 9.
31. *P. fellutanum* Biourge var. *nigro-castaneum* Abe. ..... FAT 623, 624.
32. *P. capsulatum* Raper and Fennell. FAT 564; 565.
33. *P. cyaneum* (B. and S.) Biourge. .. FAT 741.
34. *P. charlesii* Smith var. *rapidum* Abe. ..... FAT 831, 734, 806.
35. *P. velutinum* van Beyma. ..... FAT 1121, 891.

II. Asymmetrica.

1) Divaricata Sub-section.

1. *P. lilacinum* Thom. ..... FAT 1233, 1190, 1085, 1308, (1407, 1480).
2. *Spicaria violacea* Abbott. ..... FAT 1364.
3. *P. janthinellum* Biourge. ..... FAT 1156, 1167, 860, 1298, 1157, 1017, 894, 876, 217, 216, 1106, 214, 302, 1091, 687, 1192, 909, 1097, 680, 1101, 1102, 870, 861, 875, 901, 900, (1467).

Synonym: *P. oligosporum* Saito and Minoura. .. (FAT 1383, 1414).

4. *P. simplicissimum* (Oud) Thom. .. FAT 883, 542, 112, 768, 211.
5. *P. ochro-chloron* Biourge. ..... FAT 828, 1011, 1111, 678, 682, 534, 906, 880, 873, 504, 1107, 381, 991, (1468).
6. *P. piscarium* Westling. ..... FAT 711, 881, 905, (58, 1320).
7. *P. miczinskii* Zaleski. ..... FAT 1116, 882, 908, (59(.
8. *P. nalgiovensis* Laxa. ..... FAT 1489, 170.
9. *P. echinulo-nalgiovense* Abe. ..... FAT 907, 884.
10. *P. canescens* Sopp. ..... FAT 832.
11. *P. jenseni* Zaleski. ..... FAT 770, (1360).
12. *P. nigricans* (Bainier) Thom. ..... FAT 948.
13. *P. nigricans* (Bainier) Thom var. *sulfuratum* Abe. ..... FAT 536.
14. *P. melinii* Thom. ..... FAT 581, 992.

2) Velutina Sub-section.

1. *P. citrinum* Thom. ..... FAT 517, 251, 972, 1131, 1039, 219, 513, 116, 696, 600, 512, 518, 1275, 523, 537, 540, 556, 608, 93, 134, 801, 254, 821, 538, 541, 361, 973, 975, 332, 333, (1342, 1344, 1346, 1382, 1393, 1441, 1442, 1443, 1445, 1450, 1474, 1482, 1322, 1409, 187,

182, 189, 173. 165, 55, 1419, 1415, 1463, 1462).

2. *P. steckii* Zaleski. ..... FAT 509, 105, 510, 511, 98, 714, 713, 805, 802, 181, 717, 715, 716, 1040, 1063, 979, 986, 935, (181).
3. *P. citreo-virens* Abe..... FAT 319, 320.
4. *P. corylophilum* Dierckx..... FAT 706, 595, 644, 1090, 1041, (61, 62, 65).
5. *P. corylophiloides* Abe..... FAT 306, 984, 862, 308.
6. *P. paxilli* Bainier. ..... FAT 1286.
7. *P. chrysogenum* Thom. ..... FAT 1054, 917, 1020, 349, 514, 914, 533, 508, 1265, (1352, 1478, 441, 448, 458), 358, 854, 544, 506, 855, 919, 853, 700.

   Synonym: *P. camerunense* Heim. .... FAT 1472.
8. *P. chrysogenum* Thom mut. *fulvescens* Takashima, Arima and Abe. ..... FAT 515.
9. *P. meleagrinum* Biourge. ..... FAT 1222,
10. *P. meleagrinum* Biourge var. *viridi-flavum* Abe. ..... FAT 525, 652, 803, 823, 930, 1013, 1255, 1259.
11. *P. notatum* Westling. ..... FAT 1079, 577, 578, 532, 528, 530, 918, 993, 863, 612, 574, 522, 519, 865, 529, 357, 520, 616, 618, 579, 350, 980, 547, 545, (1476, 1481, 1488, 1406, 1404, 1410, 1454, 1443, 1437, 1438, 1436, 1353, 1347, 1345, 436, 445, 426, 435, 446, 447, 450, 457).
12. *P. cyaneo-fulvum* Biourge. ..... FAT 580, 635, 699, 573, 697, 596, 586, 1130, 539, (1355).
13. *P. oxalicum* Currie and Thom..... FAT 265, 258, 630, 1134, 1180, 1119, 524, 160, 834, 835, 1026, (1361, 1359).

    Synonym: *P. oxalicum* Currie and Thom var. *pectinovorum* Iwasaki... FAT 775.
14. *P. atramentosum* Thom. ..... FAT 1284.
15. *P. digitatum* Saccardo..... FAT 1331.
16. *P. digitatum* Saccardo var. *latum* Abe..... FAT 605.
17. *P. roqueforti* Thom. ..... FAT 731, 733, 1136, 1000, 1257, 1260, 1258, 1253, 42, 543, 1271, (1379, 1321, 1464, 1477).

18. *P. roqueforti* Thom var. *punctatum* Abe. ..... FAT 314, 315.
19. *P. casei* Staub. ..... FAT 817, 1046, 1030, 915.
20. *P. casei* Staub var. *compactum* Abe. FAT 1276.
21. *P. pseudo-casei* Abe. ..... FAT 317, 1166.
22. *P. brevi-compactum* Dierckx..... FAT 1285.
23. *P. stoloniferum* Thom..... FAT 684, 815, 1202, 507, 90, 709, (1319, 1466).
24. *P. brunneo-stoloniferum* Abe. .... FAT 1132.

3) Fasciculata Sub-section.

1. *P. ochraceum* Thom..... FAT 766.
2. *P. crustosum* Thom. ..... FAT 703, 735, 1133, 352, 371, 584, 593, 589, 1058, 1025, 218, 847, 553, 1227, 143, 1303, 318, 705, 1018.
3. *P. viridicatum* Westling..... FAT 818, 851, 999, 1273.
4. *P. viridi-cyclopium* Abe..... FAT 843, 1044, 321, 842, 998, 841, 1043, 1042, 1224, 263.
5. *P. olivino-viride* Biourge. ..... FAT 704, 634, 1009, 373, 997, 983, 633, 572, 636, (1323, 1453, 1350, 1349).
6. *P. palitans* Westling. ..... FAT 985, 838.
7. *P. puberulum* Bainier. ..... FAT 1304, 1262.
8. *P. cyclopium* Westling. ..... FAT 1052, 1053, 1310, 642, 840, 845.
9. *P. aurantio-virens* Biourge. ..... FAT 1226, 1225, 1118, 334, 836, 1297, 887.
10. *P. palitans* Westling var. *echino-conidium* Abe. ..... FAT 848, 1019.
11. *P. cyclopium* Westling var. *echi-nulatum* Raper and Fennell. .... FAT 987.
12. *P. urticae* Bainier. ..... FAT 1314, 1315.
13. *P. expansum* (Link) Thom. ..... FAT 736, 740. (1465, 1327).
14. *P. martensii* Biourge. ..... FAT 305, 1201. (1362).
15. *P. italicum* Wehmer. ..... FAT 744, 1330, 1329.
16. *P. corymbiferum* Westling. ..... FAT 606.
17. *P. granulatum* Bainier. ..... FAT 852.
18. *P. claviforme* Bainier..... FAT 1162, 1263, 1266, 554, 135 739.
19. *P. claviforme* Bainier mut. *candi-cans* Abe and Ura. ..... FAT 1277.
20. *P. claviforme* Bainier mut. *olivi-color* Abe and Ura. ..... FAT 1278.
21. *P. clavigerum* Demelius..... FAT 1161. (1363).

III. Biverticillata-Symmetrica.

1. *P. wortmanni* Klöcker. .....FAT 364.
2. *P. duclauxi* Delacroix.....FAT 1293.
3. *P. funiculosum* Thom. .....FAT 71, 1267.
4. *P. islandicum* Sopp.....FAT 1212, 946, 1270, 777, 778, 355. (1366, 1367).
5. *P. verruculosum* Peyronel.....FAT 1114, 301, 961, 665, 671, 354, 356, 370.

   * Synonyn: *P. echinulosporum* Nehira. .....FAT 1388.
6. *P. varians* Smith. .....FAT 1209, 949, 379, 380.
7. *P. purpurogenum* Stoll. .....FAT 1211, 1143, 376, 1149, 722, 48, 1306, 76, 1179, 1074, 47, 1141, 377, 1072, 1073. (1368, 1369, 1459, 221).
8. *P. rubrum* Stoll. .....FAT 1147, 727, 1154, 1145.
9. *P. aculeatum* Raper and Fennell. FAT 810.
10. *P. aculeatum* Raper and Fennell var. *apiculatum* Abe. .....FAT 1152, 1207, 1189, 199, 645.
11. *P. purpurogenum* Stoll var. *rubri-sclerotium* Thom. .....FAT 200, 808, 1210, 325, 316.

    * Non-sclerotigenic type.....FAT 1232, 1193, 1148, 324, 1191, 562.
12. *P. variable* Sopp. .....FAT 943, 1175.
13. *P. rugulosum* Thom. .....FAT 322, 375, 781.
14. *P. concavo-rugulosum* Abe. .....FAT 672, 198, 710, 383, 744, 683, 310, 924, 689. (1326).
15. *P. tardum* Thom. .....FAT 922, 923, 1183, 1184, 1206, 921, 378, 939, 925, 169. (1448, 1408, 1318).
16. *P. diversum* Raper and Fennell. ..FAT 1294.
17. *P. diversum* var. *aureum* Raper and Fennell. .....FAT 1295.
18. *P. herquei* Bainier and Sartory. ..FAT 951, 958, 651, 309, 1205, 953, 957, 954, 702, 264, 1028, 1313. (1372, 1373, 1458).

    * Synonym: *P. luteo-caerulea* Saito and Minoura. .....FAT 1375, 1376, 1377.
19. *P. novae-zeelandiae* van Beyma. ..FAT 1296.
20. *P. paraherquei* Abe. .....FAT 971, 964, 824, 670.
21. *P. estinogenum* Komatu and Abe. FAT 1196, 1195.

IV. Plyverticillata.

1. *P. albicans* Bainier. .....FAT 1316.

Acknowledgements

I wish to express my hearty thanks to Prof. K. Sakaguchi for his kind guidance and encouragement in this work. I am also indebted to Prof. T. Asai, Dr. K. Arima and Mr. H. Iizuka, University of Tokyo, for their valuable advice throughout, to Mr. Y. Nakano for his help with isolations of the *Penicillia*, to Dr. K. Kominami, Nagao Institute, for assigning the Latin names of the new species, varieties or mutants, and to Drs. K. B. Raper and D. I. Fennell, University of Wisconsin, and many other investigators for sending strains.

Notice: *Tables and photograph will appear in next issue.*

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Printed by
Kokusai Bunken Insatsusha
Chiyoda-ku, Tokyo, Japan.

CONTENT

S. ABE: Studies on the Classification of the *Penicillia* 1